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REGIONAL LOCATION OF PRODUCTION AND DISTRIBUTION OF FROZEN STRAWBERRIES

C. C. Dennis and L. L. Sammet

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In Cooperation With
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FOREWORD

This is the fifth in a series of reports concerning the comparative advantage of different United States producing regions in supplying frozen fruits and vegetables in the national market. The present study focuses on this problem with respect to frozen strawberries. It presents summary results of studies of production trends and present location of strawberry production in ten major producing regions, regional farm production, processing, and local freezing and storage costs as well as the costs of interregional shipment of frozen strawberries. The results also are given of estimates of regional consumption in a recent year--1955--and in a future period--1970. Finally, a summary is presented, based on the use of these data in studies of the economical allocation of total output of frozen strawberries to the various producing regions and the distribution of these regional outputs to consuming regions. This problem is considered with respect to the known production and consumption of 1955 and in regard to projected consumption for 1970. Several alternatives as to values for important determinants of production location--for example, different levels as to projected consumption, cost, and technology--are considered.

A more complete report concerning these studies of the frozen strawberry industry is in preparation, and additional work on similar studies of the important frozen vegetables is in progress.

These studies are a part of work being carried on under western regional marketing research, Project Number WM-17, in conjunction with the Experiment Stations of Oregon, Washington, and Hawaii. Participation by the California station has been in cooperation with the Agricultural Marketing Service, Marketing Economics Research Division, of the U. S. Department of Agriculture.

The authors wish to acknowledge the valuable assistance of many processors, equipment manufacturers, and materials suppliers and of many research and extension workers in the various producing regions who cooperated in the collection of data. Particularly helpful contributions were made by Robert H. Reed in securing the cooperation of processing plant operators in California and in conducting studies of plant operation, by James N. Boles in the formulation of linear programming solutions, and by R. G. Bressler in planning various phases of this study.

PREVIOUS PUBLICATIONS IN THIS SERIES BY THE GIANNINI FOUNDATION, UNIVERSITY OF CALIFORNIA, CONCERNING INTERREGIONAL COMPETITION IN FROZEN FRUITS AND VEGETABLES

Reed, Robert H., Survey of the Pacific Coast Frozen Fruit and Vegetable Industry, Mimeographed Report No. 198, September, 1957.

Dennis, C. C., An Analysis of Costs of Processing Strawberries for Freezing, Mimeographed Report No. 210, July, 1958.

Dennis, C. C., The Location and Cost of Strawberry Production, Mimeographed Report No. 217, March, 1959.

Reed, Robert H., Economic Efficiency in Assembly and Processing Lima Beans for Freezing, Mimeographed Report No. 219, June, 1959.

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REGIONAL LOCATION OF PRODUCTION AND DISTRIBUTION OF FROZEN STRAWBERRIES

by

C. C. Dennis[1/] and L. L. Sammet[2/]

INTRODUCTION

The location of strawberry production in the United States has recently undergone exceptional change, an important aspect of which has been the rapid expansion of output in California and the other Pacific Coast states. This development has seriously challenged strawberry-producing areas that, because of favorable climate or strategic location, previously occupied positions of leadership.

Of the many influences underlying this change, the most important is the increased use of freezing in the preparation of strawberries for marketing. This followed the perfection of freezing techniques for a variety of fruits and vegetables, including strawberries; the development of efficient preparation and freezing plants; and expansion of cold storage warehouse space in both producing and consuming centers. It has depended on increasing availability of specialized facilities for transportation and for retail storage and display as well as widespread installation of home freezer storage facilities.

The expanding market for frozen strawberries since World War II opened new production opportunities to regions well situated for producing processed berries. The changes in processing and marketing methods have been accompanied by technical improvements involving new varieties, improved disease and pest control, and better production equipment and methods. The influence of varietal improvements has been especially important in California where new, long-bearing varieties have extended the production and processing season. This has greatly increased the efficiency of these operations.

These developments, along with changes in per-capita consumption of strawberries in various forms, the growth in total population, and shifts in its

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distribution over the United States have profoundly affected the comparative advantage of different regions in the production and processing of frozen strawberries. This report deals with the status of regional production adjustments now in progress and with the problem of further shifts in production location that may occur in the near future.

Study Procedure

The study of interregional competition with respect to a given commodity assumes the presence, or the possibility, of locational advantage in at least some aspects of its production and distribution. Such advantages and different demands among the various consuming centers are the basis for trade flows between regions. With numerous producing and consuming centers, the pattern of these flows is determined by the interaction of economic forces in two areas. These involve: (1) product price in particular markets, as determined by the interrelated demands and supplies in the various markets; and (2) the farm production and transfer costs (for processing, storage, transportation, and other distribution services) determined for each producing region on the basis of the location of the region with respect to markets and the farm production and processing costs within the region.

In theory and in important practical respects, the study of this problem requires that the market for frozen strawberries in many individual consuming areas be considered in a way that permits estimation of the quantities taken in each market in relation to a range in market prices for frozen strawberries as well as for other products that consumers consider close substitutes--for example, fresh strawberries and other fruits. On the production side, similar analyses of the costs of producing and processing strawberries in many different regions are required. These costs need to be considered in each producing region in relation to the total regional output of strawberries and the "prices" of local resources, such as labor and land, as determined by the regional demand for their use in the production of other crops. Similarly, transportation and other transfer costs must be considered in relation to the total quantity and pattern of movement among the various producing and consuming regions. These various components of consumer demand and supply costs then must be brought together in an analysis which simultaneously considers all regional market and production relationships. The solution of this problem determines the optimum pattern as to production location and the allocation of regional outputs to various markets. If projections are made as to

production and consumption patterns in future periods, the solution requires forecasts of future demand and supply relationships. These forecasts should take account of future shifts in the capacity of strawberry production to attract land and other resources from their use in the production of other crops as well as give consideration to changes in demand determinants. An important aspect of projections regarding demand is the possibility of future change in consumer preference for frozen as compared with fresh strawberries. In such studies, the "optimum" solution usually is judged in relation to minimizing aggregate production and distribution costs. This is the criterion applied in the present study.

The problem described above is remarkably complex, and a practical solution requires the introduction of simplifications. At numerous points, therefore, useful approximations to the information ideally suited to such studies are used. Producing regions, for example, have been broadly defined in terms of ten major areas in the United States, plus Mexico; and consuming regions have been specified to comprise the 48 mainland states, plus the District of Columbia. Regional consumption has been estimated on the basis of per-capita consumption in a recent year and estimated regional population, while regional production and transfer costs--computed in simplified terms with respect to 1957-58 output--have been used in lieu of the type of regional supply-price relationships most desired. Projections for a future period--1970 was selected--are based primarily on estimates of current per-capita consumption and regional population forecasts. With these types of data, production location and possible future adjustments were studied with the aid of linear programming computational methods.

The materials which follow are confined largely to the presentation of the results of these studies. More details will be found in other publications.1/

1/ A study of processing costs in California--the results of which were later adjusted for application to other regions--was reported in Dennis, C. C., An Analysis of Costs of Processing Strawberries for Freezing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, July, 1958), 77p. (Giannini Foundation Mimeographed Report No. 210.) Processed. Estimates of farm production costs for strawberries were presented in Dennis, The Location and Cost of Strawberry Production (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, March, 1959), 25p. (Giannini Foundation Mimeographed Report No. 217.) Processed. In addition, materials developed by the U. S. Department of Agriculture, the National Association of Frozen Food Processors, and other agencies were drawn upon.

Descriptive Background

The study of locational advantage in the production and processing of frozen strawberries is aided by description of the production trends and regional characteristics of this industry. In this the close link between the fresh and processed markets is recognized, although the major interest is in processed berries.

Trends in Total Production

Total annual strawberry production in the United States was relatively stable during the 1920's and early 1930's. It decreased somewhat during the mid-1930's and nearly recovered to previous levels just before World War II. Production during the war period decreased drastically, dropping over 45 per cent from 1942 to 1943 and nearly 30 per cent more from 1943 to 1944. Since 1946, however, a gradual increase has been experienced, as shown in Figure 1. Total production in the 11-year period 1946-1957, increased by 295,000,000 pounds or 115 per cent. The 1955 production was nearly equal to that of 1942 and only slightly below the record heavy volume of 1929. Both 1956 and 1957 set new records for strawberry production.

Total strawberry production is utilized in two main forms, fresh and processed. The postwar production gains are mainly in processed output. This has expanded by almost 350 per cent since 1946, as compared with a 50 per cent growth in the production of fresh berries. Most of the growth in processed output occurred in the production of frozen strawberries, which now account for 85 to 90 per cent of total processed output.

Regional Composition and Production Patterns

For this study, the United States was divided into the ten producing regions shown in Figure 2. In addition, Mexico was treated as a supplementary region to permit consideration of imports from that country. The regions were selected to define separate areas of relatively concentrated production and to include in each region contiguous areas of minor production. The geographic extent of the region thus defined does not indicate the volume of actual production, nor is the location of major producing centers within regions specified. Major production centers are roughly indicated in Figure 2, however, by listing first for each region the state that contains the primary production center of that region. While a logical grouping was achieved, many alternatives to that selected are possible.

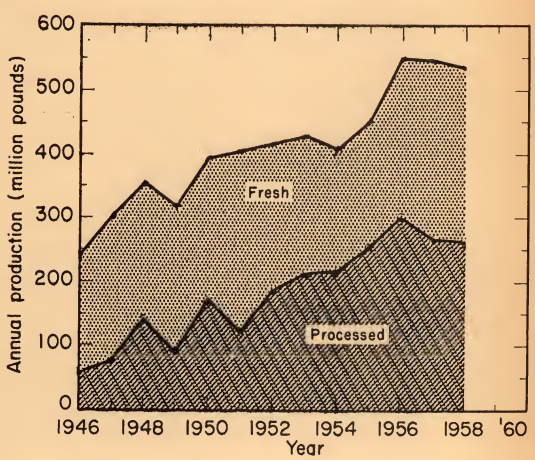

Figure 1. Annual strawberry production in the United States, 1946-1958.

Source: U. S. Agricultural Marketing Service, Marketing California Strawberries, 1955 Season and 1958 Season (San Francisco: Federal-State Market News Service, April, 1956, and May, 1959).

Region	States included
1	New York, Pennsylvania, Connecticut, Massachusetts, Maine
2	Michigan, Ohio, Indiana, Wisconsin, Iowa
3	Virginia, North Carolina, South Carolina, Maryland, Delaware, New Jersey
4	Tennessee, Kentucky, Illinois
5	Arkansas, Missouri, Oklahoma, Kansas
6	Florida
7	Louisiana, Texas, Alabama
8	Washington
9	Oregon
10	California

FIGURE 2. Ten Geographical Regions Used in the Analysis of Strawberry Production.

Regional production characteristics of special interest are trends in total production, yield per acre, and harvesting season.

Production

Not all regions of the country have shared equally in the recent production increases--some have even decreased. Regions 3, 4, 5, 6, and 7 (roughly the southeastern quarter of the United States) have declined in total strawberry production in the period since 1946, although the trends in Regions 4 and 6 are not pronounced. Regions 1 and 2 have had small average annual increases in total production. Major increases have occurred only in Regions 8, 9, and 10--the Pacific Coast states. With the exception of Region 1, increases in total annual output have occurred only in regions processing a fairly large quantity of strawberries. This is especially true in Regions 8 and 9, which produce almost exclusively for processing. Region 10 (California), on the other hand, has rapidly increased production for both the fresh and processed markets.

Yield Per Acre

Total production changes reflect changes in total acreage and in yield per acre. And acreage changes are often due, at least in part, to the cost-changing influence of yield changes of previous years. Comparison of average yield data for the two 6-year postwar periods--1946-1951 and 1952-1957--suggest two regional groupings with respect to yields. In one, comprising Regions 1 to 7, average yields during the two periods were roughly the same. They ranged from about 2,000 pounds per acre in Region 5 to slightly over 3,000 pounds per acre in Regions 1 and 2. In a second grouping--Regions 8 to 10--yields averaged higher in both periods than in the first grouping, and there were substantial increases in average yields in the second as compared with the first six-year period. In Regions 8 and 9, average yield increased from considerably over 3,000 pounds per acre during the period 1946-1951 to roughly 4,200 pounds per acre in 1952-1957. Meanwhile, average yields in Region 10 increased from about 11,000 pounds to 13,000 pounds per acre. The regions of large increase in yield per acre--Regions 8, 9, and 10-- are also the regions having recent large increases in total production for processing. At the same time, Regions 2, 4, and 5, the only other regions in which processing has been important to the strawberry industry of the region, have had slightly decreasing average yields and have failed to show much increase in quantities processed.

Harvesting Season

The harvesting season is important in two respects: date of harvest and length of harvest period. Region 6, with a production period extending from mid-December through April, has a strong potential as a supplier of fresh markets. This is true also of Region 7, in which the harvest season runs through April to mid-May, and Regions 3, 4, and 5, in which the season extends from mid-April to mid-June. In Regions 1, 2, 8, and 9, the season extends through May, June, and July. This harvest period, and location near large consuming centers, gives special advantage to Region 1 in the marketing of fresh berries during the late spring and early summer months. This is also true of Region 2, although a substantial quantity of strawberries in Region 2 is frozen. Great distance from major fresh markets not pre-empted by Region 10 gives potential importance to Regions 8 and 9, primarily in the production of processed berries. In Region 10, a long harvest season, extending through the 11 months January to November, makes this area a competitor in the marketing of both fresh and processed berries.

Approach to Empirical Analysis

The regional production pattern described briefly above and a regional consumption pattern--developed in a later section--are tangible elements of inter-regional competition in the production and marketing of strawberries in the United States. The trends in regional production and in the relative importance of the fresh and processed markets suggest the possibilities of further shifts in the competitive relationships among different regions. These relationships and their effects on the location of strawberry production are subjected to empirical study in the remainder of this report.

REGIONAL PRODUCTION AND TRANSFER COSTS

The various components of cost considered include farm production, processing, storage, wholesaling, and transportation to market. The local costs of distribution and retailing in each market are omitted on the basis that they are independent of the source of the berries consumed in a given market and so have no effect on the location of production. The results of cost computations for the remaining components are given below.

Regional Farm Supply Price

Farm production costs for the ten producing regions defined in Figure 2 were estimated in terms of farm budgets developed through interviews with groups of producers in each region.[1] A single value as to production cost in 1958 was obtained for each region. This departs considerably from the form of estimate desired, which would indicate the amounts supplied in each region at different prices. Its use in studies of production location requires the assumption that relevant changes in quantity produced in any region will not appreciably affect the farm supply price.

Circumstances applying to strawberry production make the use of a single value for regional farm supply price a less drastic simplification than would be true for most commodities. For example, the prices of many of the important materials and services used in strawberry production--such as tractors and fertilizers--are determined in a national market and so may be assumed to be unaffected by local shifts among alternative crops. Such an assumption, however, is less safely applied to the basic resource, land, and in some situations to labor and other factors.

A special circumstance applies, however, to the land used in strawberry production because the land resources required are not highly specialized and they constitute only a small percentage of total cropland in the United States. In fact, total current processed output in this country probably could be produced in any one of the present major regions without requiring substantial diversions from land use in other crops. In California, for example, processed output in 1958 amounted to 133,500,000 pounds in a total United States processed output of 263,800,000 pounds. With an average 1958 yield of 12,800 pounds per acre, this output required approximately 10,500 acres of California farm land. Production of the total United States processed volume of 263,800,000 pounds in California would have required an addition of about 10,000 acres in this crop. In relation to total acreage adaptable for strawberry production in California, a shift of this magnitude probably would not have a significant effect on the cost of land used in strawberry production.[2]

1/ The results of the study of farm production costs for strawberries are more fully reported in Dennis, The Location and Cost . . . .

2/ While labor might also prove to be a limiting factor in some situations, considerable flexibility in labor supply exists in most regions--for example, through the use of transient and vacation-period labor and, in some regions, through the importation of foreign nationals under labor contract.

The method used in estimating farm supply price is further supported by recent technological developments in strawberry production. In California, for example, these include a new variety, the Solana, which is currently being introduced in commercial production.[1] This variety promises high yield per acre and is reported to be of high quality and well adapted to processing use.[2] Its cultural requirements are less restrictive than for some varieties now in commercial production; and it appears likely that it can be grown successfully outside the relatively cool midcoastal areas now the major source of California processed berry production. Also, economical techniques for control of verticillium wilt have recently been developed. Pressures for new land to escape the effects of wilt, therefore, may be eliminated or greatly reduced. The potential for some--if not all--of the above types of development is present in all regions, and this adds to the plausibility of the assumptions made here in empiric approximations of strawberry supply prices.

Regional supply prices on the above basis were estimated for 1958, using prices for labor, equipment, materials, and other services appropriate for each region. The objective in the budgeting procedure was to determine the average production costs--including harvesting and delivery to the processing plant--of representative commercial growers. The costs of all inputs were considered, including land, buildings, machinery expense, materials, and labor. Average costs were determined by dividing total costs by the yield expected during the life of the planting. Where equipment units customarily are used in the production of more than one crop, their costs were allocated in proportion to expected annual use with each crop.

The results of the regional farm production cost studies are given in Table 1, in which three groupings with respect to average cost are apparent. The lowest cost group--with costs in cents per pound given in parentheses--is composed of Washington (9.5), Oregon (9.7), and California (9.6). The next group is composed of Michigan (11.5), Tennessee (11.6), Virginia (12.6), New York (13.8), and Arkansas (16.7). Highest costs were found in Louisiana (23.1) and Florida (25.1). The differences among regions are traceable to several variations in local

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1/ Of new plantings in 1959 in the southern coastal area of California, approximately 10 per cent are reported to be of the new Solana variety.

2/ For production possibilities with the Solana variety, see Bringhurst, R. S. and Victor Voth, "Summer Planted Solana Berries," California Agriculture, vol. 13, no. 4, April, 1959, p. 6.

TABLE 1

Nonharvest, Harvest, and Total Farm Production Costs
Per Pound in Ten Regions of the United States, 1958

Region	State	County	Cost per pound		
			Harvest[a/]	Nonharvest	Total[a/]
			cents		
1	New York	Erie and Chautauqua	7.1	6.7	13.8
2	Michigan	Berrien	9.2	4.7	13.9
2	Michigan	Manistee	7.2	4.3	11.5
3	Virginia	Accomac and Northampton	9.6	3.0	12.6
4	Tennessee	Cumberland	7.5	4.2	11.7
4	Tennessee	Macon	7.7	3.9	11.6
4	Tennessee	Madison	9.2	3.1	12.3
5	Arkansas	White	10.0	6.7	16.7
6	Florida	Hillsborough	15.1	10.0	25.1
7	Louisiana	Tangiapahoa	10.5	12.6	23.1
8	Washington	Whatcom	4.8	4.7	9.5
9	Oregon	Yamhill	6.6	3.1	9.7
10	California	Monterey and Santa Cruz	4.5	5.1	9.6
10	California	Stanislaus	6.7	6.7	13.4

a/ Includes cost of delivery to packing house.

circumstances such as: life of planting--which typically varied among regions from one to three or more years; acreage per grower--in which the range of representative acreage varied from two to twenty acres per grower; yields--which ranged from slightly over 2,100 pounds per acre in Arkansas to nearly 23,000 pounds per acre in California; and labor wage rates--where the "going" rate varied among regions from $0.50 to $1.50 per hour.

Regional Processing Costs

Regional differences in costs of processing strawberries for freezing, while not as large as regional differences in farm production costs, are in some situations sufficient to swing the balance of production advantage in terms of total cost from one region to another. Determination of regional processing cost was, therefore, given considerable emphasis in this study. This involved determination of the level of unit total cost attainable with current prices for labor, equipment, and other services in plants efficiently organized with respect to methods and equipment now available.[1/] The estimates used are based on detailed studies in California plants, the results of which were adapted to reflect cost relationships in other regions.

California Processing Costs

The costs of processing strawberries for freezing were synthesized in economic-engineering studies based on observation of actual processing operations.[2/] The basic data were obtained in intensive studies of seven California strawberry

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1/ While processing costs were studied with respect to the effect of variation in plant capacity rate, length of operating season, proportion of culls, and other factors, no attempt was made to determine the effect of regional total output on processing costs. The results thus depart from the theoretical concept of long-run supply price, but the departure is of minor degree. Nearly all the important inputs--except labor--are priced in a national market and many--such as conveyors and filling machines--are types widely used throughout the food processing industry. Shifts in the volume of strawberries processed in a given region would, therefore, have little effect on long-run regional supply price of processing services, except as such shifts affect the economical capacity rate of individual plants.

2/ Only a brief summary as to the type of plant cost study and results is given here. For details, see Dennis, An Analysis of Costs. . . . The methodology of the processing plant studies is given in French, B. C., L. L. Sammet, and R. G. Bressler, "Economic Efficiency in Plant Operations with Special Reference to the Marketing of California Pears," Hilgardia, vol. 24, no. 19, July, 1956, pp. 543-721.

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[illegible]

processing plants, ranging in capacity output rate from 7,500 to 25,000 pounds per operating hour. In these plants, time and production studies were made of particular jobs and machine operations. In addition, accounting records and interviews with management and supervisory personnel were obtained to provide further information as to labor utilization and output, machine capacities, general expense categories, and factor prices. Similar data obtained in ten plants processing Lima beans for freezing provided additional information in regard to certain cost components.1/ Data concerning equipment costs and performance characteristics were obtained from several major equipment manufacturers, local equipment fabricators, and contractors.

Data of the type described above were used to develop, in relation to specified outputs, estimates of the physical quantities of labor, equipment, and other services and materials required in the performance of particular operations. These quantity estimates were converted to costs through the application of appropriate prices. Comparison of costs with different methods provided a basis for selecting the least-cost method of performing each operation studied. The costs so determined for all direct operations--and for indirect cost components such as the plant buildings, general supervision, and administrative and general expense--were then combined to give an estimate of total plant cost. Such calculations, performed with respect to a range of operating conditions, provided a basis for estimating processing costs in relation to differences in length of operating season, proportion of sort-out berries, capacity rate of plant output, and type of container.

Regional Processing Costs

Processing cost relationships for the regions defined in Figure 2 were developed through appropriate adjustment in the costs established for California plants. This required consideration of regional differences in factor prices and length of operating season and their effect on the choice of economical methods for performing individual operations and in organizing the complete plant. The results of this procedure disclosed a considerable range in regional processing costs, attributable in part to differences in wage rates and length of

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1/ The results of the study of Lima bean processing costs are reported in Reed, Robert H., Economic Efficiency in Assembly and Processing Lima Beans for Freezing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, June, 1959). (Giannini Foundation Mimeographed Report No. 219.)

operating season. For the purposes of later analysis, certain common characteristics among regions were specified. These--assumed not appreciably to diminish the realism of the results--are summarized below.

1. Berry quality is one of the determinants of strawberry processing cost. In the absence of regional information concerning the quality of strawberries received for processing, the assumption was made of uniform quality. Sort-outs plus rots averaged approximately 10 per cent in the California plant studies, and this percentage is used as a basis of cost comparison.

2. Worker efficiency does not vary among regions.

3. In each region, the most efficient processing techniques are used in all phases of the operations.

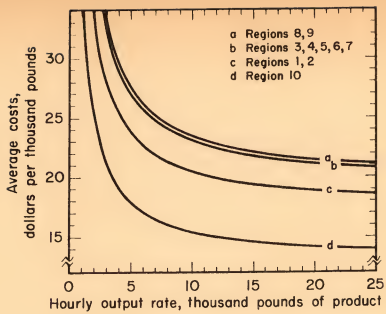
4. Length of processing season may vary among plants in a given region as well as among different regions. A representative figure for annual operating hours for plants in Regions 3 to 7, inclusive, is estimated as 150 hours; of plants in Regions 1, 2, 8, and 9--200 hours; and of plants in Region 10--1,000 hours.

5. The entire amount of processing plant fixed costs in Region 10 is allocated to strawberry processing, as strawberry processing plants in this region usually have no other output. In all other producing regions, however, strawberry freezing plants also process other products, and plant fixed costs are allocated to the various products in proportion to the customary annual use with each product.

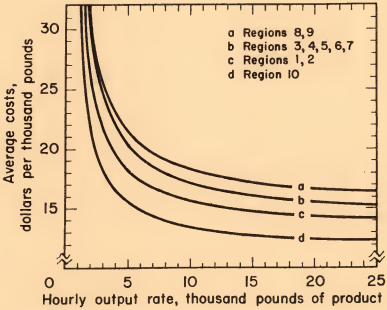
6. Processing costs are based on the assumption that only a single type of container is used in a given plant. Most plants, in fact, produce berries in several different types of containers, and in such operations slightly different unit costs with a given type of container are obtained as compared with single-container operation. Relative costs among regions, however, are not appreciably affected by this assumption.

7. Since the analysis of interregional competition presented in a later section is made on the simplified basis of only two forms of output--a retail package in 10-ounce cartons, packed 24 cartons per case, and a 30-pound tin--adjusted costs were computed only for these two types of container.

A summary of results conforming to the above specifications is presented for 10-ounce cartons and 30-pound tins in Figure 3. These charts indicate that, with either type of container, costs are substantially lower in large- as compared with small-capacity plants; that processing costs in Region 10 are well below those in Regions 1 and 2, while costs in the latter regions are appreciably lower than in Regions 3 to 9. Comparison of the two charts will show costs per pound with the carton-type pack to be slightly higher than with the 30-pound tin (container and sugar costs excluded).



A. 10-OUNCE CARTONS, 24 CARTONS PER CASE



B. 30-POUND TINS

Figure 3. The effect of type of container and plant capacity output rate on the costs of preparing strawberries for freezing in ten producing regions of the United States, 1958. (Costs in all regions based on manual removal from inspection belt of 10 per cent of the total berries run and a 4 to 1 berry-sugar ratio. The cost of materials--raw product, sugar, and containers--is not included.)

a/ While a single cost relationship is shown for each regional group, there were minor differences in estimated costs among the regions in each group. The differences within regional groups, however, were too small to demonstrate graphically.

Total Processed Product Cost

The at-plant cost of frozen strawberries in each region is composed of the costs of farm production and delivery to the processing plant, preparing the berries for freezing, sugar, containers, and freezing. Estimated costs for these components are given by region in Table 2 for 10-ounce and 30-pound containers packed in plants of 10,000 and 25,000 pounds per hour capacity. Since the costs in this table are expressed in relation to net weight of packed berries, it was necessary to convert to a packed output basis the unit farm production costs previously given in relation to farm output (the raw-product plant input).

Table 2 indicates that California, closely followed by Washington and Oregon, holds an advantage in total at-plant frozen product cost. Among eastern regions, costs are lowest in Regions 2 and 4.

Transportation Costs Between Producing and Consuming Regions

The cost of transporting frozen strawberries from the producing region to the consuming region is the final cost component considered. Estimates of these costs are based on the level and structure of truck and rail rates in two recent periods. Data for 1955 are applied in an analysis of the efficiency with which the produced supply of that year was allocated to the various consuming regions, while rates for 1957 are used in studies based on projected consumption in 1970. The application of current rates to projected 1970 conditions is, of course, not an ideal procedure, but these are the best available indication of rates in nearby future periods. They are considered particularly useful indicators of the relative level of rates among different regions in future periods.[1/]

Rates in 1955 and 1957

The basic transportation rate information used appears in a recent publication of the U. S. Department of Agriculture, which gives average 1955 and 1957

1/ Changes in transportation rates which do not alter the structure of absolute differences in the costs of product movement among the various regions would not invalidate the findings of this study. Effective resistance of shippers in different regions to changes in rates that would alter the present transportation cost relationships among regions may be expected, and this lends support to the assumption of stability in rate structure that is incorporated in the analysis.

TABLE 2

Total Processed Product Cost in the Preparation of Strawberries for Freezing in Relation to Producing Region, Type of Container, and Plant Capacity Output Rate, 1958

Region and type of container	Farm[a]	Plant: 10,000-pounds-per-hour capacity	Plant: 25,000-pounds-per-hour capacity	Sugar[b]	Container[c]	Freezing and first month's storage	Total at-plant cost[d]: 10,000-pounds-per-hour capacity	Total at-plant cost[d]: 25,000-pounds-per-hour capacity
	cents per pound of product							
10-ounce cartons								
1	12.267	2.047	1.858	1.941	4.933	.713	23.324	23.123
2	10.222	2.042	1.854	1.876	4.933	.875	21.245	21.044
3	11.200	2.297	2.065	1.936	5.000	.700	22.507	22.260
4	10.311	2.311	2.079	1.943	4.933	.942	21.763	21.522
5	14.844	2.392	2.160	1.935	4.933	.942	26.674	26.427
6	22.311	2.281	2.052	1.937	5.067	1.100	34.821	34.577
7	20.533	2.286	2.056	1.840	5.000	1.100	32.758	32.513
8	8.444	2.345	2.112	1.947	4.933	.850	19.723	19.474
9	8.622	2.345	2.112	1.929	4.933	.850	19.893	19.644
10	8.533	1.537	1.389	1.855	4.933	.875	18.886	18.728
30-pound tins								
1	12.267	1.571	1.417	1.941	1.267	.633	18.828	18.664
2	10.222	1.564	1.411	1.876	1.233	.747	16.659	16.496
3	11.200	1.711	1.521	1.936	1.267	.640	17.843	17.641
4	10.311	1.727	1.537	1.943	1.233	.848	17.104	16.904
5	14.844	1.717	1.526	1.935	1.233	.848	21.914	21.711
6	22.311	1.695	1.508	1.937	1.300	.983	30.061	29.862
7	20.533	1.699	1.512	1.840	1.267	.983	28.033	27.834
8	8.444	1.831	1.641	1.947	1.400	.620	15.168	14.964
9	8.622	1.826	1.639	1.929	1.400	.620	15.338	15.134
10	8.533	1.337	1.218	1.855	1.400	.800	14.830	14.703

a/ Ten per cent of raw product assumed removed from sorting belt. Thus, 1.1111 pounds of raw product are required for 1 pound of frozen berries. A 4 + 1 berry-sugar ratio is assumed so 80 per cent of the product is strawberries (20 per cent sugar). Therefore, to find the cost of strawberries in 1 pound of product, the farm production price is multiplied by 1.1111 and this in turn is multiplied by 0.8.

b/ Since 20 per cent of the frozen product is assumed to be sugar, the cost of sugar in the product is 0.2 times the price of sugar. Regional sugar prices (per pound), based on estimates of sugar companies and brokers, are (1) 9.703, (2) 9.378, (3) 9.680, (4) 9.717, (5) 9.676, (6) 9.684, (7) 9.200, (8) 9.737, (9) 9.644, and (10) 9.277.

c/ Estimated container costs are: For 10-ounce cartons per case of 24 (all materials): regions 1, 2, 4, 5, 8, 9, and 10--74 cents; regions 3 and 7--75 cents; and region 6--76 cents. For 30-pound tins (each): regions 2, 4, and 5--37 cents; regions 1, 3, and 7--38 cents; region 6--39 cents; and regions 8, 9, and 10--42 cents.

d/ Sum of costs given in this table plus 6½ per cent of these costs to cover processor selling costs.

refrigerated truck and rail-car rates for transporting frozen fruits and vegetables from many producing states into 12 major cities.[1] The 1955 rates in this report are as published by the Interstate Commerce Commission for truckloads and carlots. These were used as a basis for estimating the average relationship between rate per 100 pounds gross weight and length of haul.[2] Comparison of the rail and truck rate-distance relationships thus obtained indicates truck transportation to be lowest in cost for distances not in excess of about 1,220 miles, while rail transportation is least in cost for greater distances. Since this break-even point is based on "average" relationships, it does not necessarily apply to specific point-to-point movements. This is particularly true if the comparisons are based on the zone rate structure used in rail transportation in which the rate increases in discontinuous steps as distance increases. Another important difference in the truck and rail-rate structures is that beyond roughly 1,200 miles, rail transportation rates increase very slightly with increased distance, while truck rates appear to increase uniformly--and much more steeply than rail--as distance increases.

1/ U. S. Agricultural Marketing Service, Marketing Research Division, Interstate Trucking of Frozen Fruits and Vegetables Under Agricultural Exemption (Washington: Govt. Print. Off., March, 1959), 88p., Tables 31-42, inclusive. (U. S. Department of Agriculture Marketing Research Report No. 316.)

2/ Truck transportation rates were found to increase in a logarithmic manner in the lower distance range, but arithmetically in the higher range. A logarithmic regression on observations up to 500 miles and an arithmetic regression on all observations gave the following results:

For distances less than 500 miles, $\log C_t = 0.677577 + 0.512363 \log D$ ($r^2 = 0.45$)

For distances 500 miles or more, $C_t = 57.776 + 0.112428D$ ($r^2 = 0.94$)

in which C_t is the truck transportation cost in cents per 100 pounds gross weight and D is the distance in miles.

Rail rates present a different pattern, the short-haul logarithmic relationship observed with truck rates being absent. Also, the zone rate structure for rail transport is quite noticeable, especially for long-haul movements. If average linear relationships are computed, two equations--reflecting different relationships for long- and short-haul rates are obtained as follows:

For distances less than 1,000 miles, $C_r = 63.390745 + 0.108829D$ ($r^2 = 0.79$)

For distances of 1,000 or more miles, $C_r = 166.970102 + 0.013027D$ ($r^2 = 0.33$)

in which C_r is the rail transportation rate in cents per 100 pounds gross weight and D is the distance in miles.

The trucking and rail rates described above are not strictly comparable, because greater costs of loading, unloading, and handling are incurred when shipping by rail than by truck. The difference, based on information supplied by local freezing and storage firms, is estimated at 12 cents per 100 pounds (gross weight). To put rail and truck rates on a comparable basis, this amount is added to the estimated rail rates per 100 pounds.

Rate relationships for rail transportation were similarly developed for 1957 on the basis of representative Interstate Commerce Commission rates as published in the U. S. Department of Agriculture study. This was not possible, however, for truck rates in 1957 because of recent changes in the status of Interstate Commerce Commission regulation of frozen food shipments. These products originally had moved in interstate shipments under regulated rates, but court decisions in 1955 freed them from Interstate Commerce Commission regulation. The use of nonregulated carriers subsequently reduced trucking charges to the extent that, in 1957, the average of regulated and nonregulated trucking rates was 15 per cent below the 1955 average. During the same period, rail rates increased an average of 10.8 per cent.

Frozen fruits and vegetables were returned to a regulated status by Congressional act in 1958, making the trucking rates for 1957 obsolete. Since the regulated rates later established were not available at the time of this study, it was necessary to adjust the most recently available regulated trucking rates to a level that would have prevailed under regulation. On the assumption of a parallel movement in regulated rail and truck rates, the regulated trucking rates for 1955 were increased by 10.8 per cent to establish a level that presumably would have prevailed in 1957.

Distances

Transportation rates are calculated from a given point of origin to a given point of destination. There are many points of origin in each producing region and many points of destination in each consuming region. To consider every possible point-of-origin, point-of-destination combination would be far beyond the capability--or interest--of this study. The objective here is to determine general relationships, and for this purpose representative transportation distances and resulting cost relationships can be employed.

In most regions, strawberry production is distributed more or less evenly over a wide area or concentrated in two or more locations. In this study, a point near the geographic center of production of each region was chosen to

represent all points of origin of the region. Similarly, a point near the population center of each consuming region was chosen as the regional point of destination. This limits each production region to one point of origin and each consuming region to one point of destination and reduces the possible origin-destination flows to manageable proportions. This necessary simplification makes possible a solution--one which approximates the result which would be obtained if all possible origins and destinations were explicitly included.

Points chosen to represent each producing region and the consuming center of each consuming region (state) are given in Table 3, which also gives the distances between each of these producing and consuming points. The distances given in Table 3 are taken from the Household Goods Carriers' Bureau, Mileage Guide No. 4.1/ Interregional transportation costs are based on these distances between producing and consuming "points."

Interregional Transportation Costs

Unit costs of transportation between selected production and consuming centers were computed on the basis of the rate and distance data described above. Truck rates for 1955 were calculated from the average rate-distance relationship developed for truck transportation, while published zone rates were used in determining rates for rail shipment. The results are given in Table 4. The table is based on the least-cost method of shipment for any given movement and so reflects the use of truck transportation for shipments under 1,220 miles and rail facilities for greater distances.

The rates given in Table 4 apply to the gross weight shipped, including product, container, and shipping materials. To differentiate transportation rates by type of container and to enable combination of transportation costs with other cost components, it is necessary to place them on a net weight basis. This was done by application of appropriate conversion ratios to the transportation costs based on gross weight.2/ Net transportation costs calculated on the basis of the gross weight of a given quantity of product are given for 10-ounce cartons (24 cartons per case) and 30-pound tins in Appendix Tables A and B.

1/ Household Goods Carriers' Bureau, Mileage Guide No. 4 (Washington, D. C.: December 15, 1941).

2/ The conversion was made as follows: A case of 24 10-ounce cartons contains 15 pounds of product. Cartons and shipping materials for one case are estimated to weigh 2.5 pounds, making a gross weight of 17.5 pounds. A 30-pound container (net weight) is estimated at 32 pounds gross weight. With these unit weights, the ratio for converting net to gross weight is 1.16667 for 10-ounce cartons and 1.06667 for 30-pound containers.

TABLE 3

Mileages Between Points in Producing and Consuming Regions

Consuming state	City to which mileage is estimated	Producing region[a]										
		1	2	3	4	5	6	7	8	9	10	Mexico
		miles										
Maine	Portland	524	1,031	769	1,251	1,561	1,513	1,722	3,144	3,275	3,348	2,837
New Hampshire	Concord	437	944	703	1,166	1,474	1,447	1,656	3,057	3,188	3,261	2,750
Vermont	Burlington	410	917	739	1,139	1,447	1,483	1,655	3,030	3,161	3,234	2,723
Massachusetts	Boston	460	967	664	1,146	1,497	1,408	1,617	3,080	3,211	3,284	2,744
Rhode Island	Providence	456	963	622	1,110	1,456	1,366	1,575	3,076	3,207	3,277	2,702
Connecticut	New Haven	419	883	520	1,002	1,354	1,264	1,473	2,996	3,110	3,175	2,600
New York	Albany	265	792	588	1,014	1,322	1,332	1,504	2,905	3,036	3,109	2,598
New Jersey	Trenton	357	760	386	868	1,231	1,130	1,339	2,873	2,987	3,052	2,466
Pennsylvania	Harrisburg	299	636	331	756	1,107	1,072	1,227	2,749	2,860	2,928	2,334
Ohio	Sandusky	250	260	611	503	793	1,145	1,080	2,373	2,504	2,577	2,065
Indiana	Indianapolis	489	256	732	303	551	1,018	839	2,273	2,331	2,372	1,823
Illinois	Chicago	534	179	878	157	603	1,184	933	2,089	2,226	2,299	1,901
Michigan	Lansing	414	99	766	535	785	1,222	1,084	2,295	2,424	2,497	2,068
Wisconsin	Madison	622	267	966	545	677	1,272	1,011	2,014	2,151	2,319	1,975
Minnesota	Minneapolis	963	608	1,307	853	619	1,582	1,203	1,660	1,797	2,105	1,906
Iowa	Des Moines	870	513	1,199	670	361	1,397	945	1,849	1,884	1,957	1,648
Missouri	Jefferson City	860	546	1,089	430	212	1,151	718	2,100	2,047	2,004	1,511
North Dakota	Jamestown	1,298	943	1,642	1,191	863	1,918	1,482	1,363	1,500	1,843	2,060
South Dakota	Sioux Falls	1,036	732	1,431	951	541	1,671	1,160	1,573	1,710	1,803	1,772
Nebraska	Omaha	1,010	653	1,322	787	360	1,490	979	1,745	1,745	1,818	1,617
Kansas	Wichita	1,201	883	1,433	746	203	1,388	766	1,911	1,835	1,660	1,301
Delaware	Dover	421	758	188	838	1,226	1,100	1,309	2,870	2,985	3,047	2,436
Maryland	Baltimore	375	658	255	737	1,125	999	1,208	2,771	2,885	2,958	2,335
District of Columbia	Washington	404	667	217	699	1,124	961	1,170	2,780	2,894	2,945	2,279
Virginia	Richmond	494	755	107	636	1,169	851	1,107	2,860	2,963	2,961	2,234
West Virginia	Charlestown	435	503	418	419	913	913	998	2,566	2,645	2,675	2,003
North Carolina	Raleigh	633	854	136	562	1,095	694	983	2,917	2,996	2,887	2,110
South Carolina	Columbia	813	878	387	465	1,003	492	791	2,895	2,935	2,735	1,918
Georgia	Macon	992	896	589	349	862	387	589	2,863	2,826	2,571	1,716
Florida	Tampa	1,309	1,274	861	727	1,185	0	736	3,235	3,182	2,826	1,865
Kentucky	Louisville	547	369	694	190	575	914	767	2,386	2,417	2,399	1,769
Tennessee	Nashville	732	559	714	0	543	727	577	2,514	2,477	2,325	1,601
Alabama	Birmingham	932	777	768	218	628	557	401	2,678	2,625	2,340	1,528
Mississippi	Jackson	1,135	911	1,021	403	550	696	173	2,591	2,504	2,130	1,275
Arkansas	Little Rock	1,075	815	1,074	360	280	952	364	2,360	2,303	1,971	1,241
Louisiana	Baton Rouge	1,309	1,084	1,169	577	644	736	0	2,598	2,511	2,137	1,133
Oklahoma	Oklahoma City	1,282	1,000	1,424	710	242	1,289	609	2,034	1,947	1,615	1,139
Texas	Waco	1,500	1,222	1,485	785	464	1,144	443	2,230	2,143	1,750	835
Montana	Lewistown	1,856	1,501	2,200	1,747	1,351	2,476	1,931	821	958	1,327	2,271
Idaho	Boise	2,291	1,934	2,600	2,014	1,575	2,719	2,048	550	463	748	2,155
Wyoming	Casper	1,605	1,215	1,949	1,377	950	2,082	1,502	1,160	1,165	1,268	1,842
Colorado	Denver	1,553	1,198	1,801	1,199	719	1,996	1,211	1,413	1,326	1,364	1,545
New Mexico	Albuquerque	1,800	1,482	1,978	1,284	774	1,765	1,076	1,543	1,456	1,061	1,172
Arizona	Phoenix	2,243	1,925	2,421	1,707	1,217	2,171	1,465	1,577	1,336	715	1,320
Utah	Salt Lake City	1,981	1,624	2,290	1,704	1,221	2,361	1,672	926	839	846	1,779
Nevada	Reno	2,510	2,153	2,819	2,233	1,742	2,799	2,110	778	537	384	2,104
Washington	Seattle	2,623	2,268	2,967	2,514	2,105	3,435	2,598		241	563	2,705
Oregon	Salem	2,754	2,397	3,063	2,477	2,038	3,182	2,511	241	0	722	2,618
California	Bakersfield	2,648	2,330	2,826	2,112	1,622	2,613	1,924	1,075	834	213	1,822

[a] Mileages estimated from the following cities (numbers refer to producing region): (1) Buffalo, New York; (2) Muskegon, Michigan; (3) Norfolk, Virginia; (4) Nashville, Tennessee; (5) Joplin, Missouri; (6) Tampa, Florida; (7) Baton Rouge, Louisiana; (8) Seattle, Washington; (9) Salem, Oregon; (10) Salinas, California; and (Mexico) Irapuato, Guanajuato.

Source: Household Goods Carriers' Bureau, Mileage Guide No. 4 (Washington, D. C., December 15, 1941).

TABLE 4

Estimated Between Points Transportation Rates for Frozen Fruits and Vegetables, Gross Weight Basis, 1955a/

Consuming state	Producing region										
	1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	117	174	144	212	174	190	196	216	216	216	242
New Hampshire	107	164	137	189	174	196	196	216	216	216	242
Vermont	104	161	141	186	174	196	196	216	216	216	242
Massachusetts	109	166	132	187	174	196	196	216	216	216	242
Rhode Island	109	166	128	148	174	196	196	216	216	216	242
Connecticut	105	157	116	170	174	196	196	216	216	216	242
New York	86	147	124	172	174	196	196	216	216	216	242
New Jersey	97	143	101	155	174	185	196	216	216	216	221
Pennsylvania	88	152	93	143	182	178	196	216	216	216	221
Ohio	81	82	126	114	147	187	179	212	212	212	221
Indiana	113	82	140	89	120	172	152	212	212	212	221
Illinois	118	68	156	109	126	191	163	196	196	196	221
Michigan	104	50	144	118	146	212	180	212	212	212	221
Wisconsin	128	83	166	119	134	212	171	196	196	196	221
Minnesota	166	126	216	154	127	212	193	189	189	196	221
Iowa	156	115	193	133	97	212	164	189	189	189	221
Missouri	154	119	180	106	74	187	139	189	189	189	202
North Dakota	216	164	216	192	155	216	196	181	181	181	221
South Dakota	174	140	216	165	119	216	188	181	181	181	221
Nebraska	171	131	216	146	97	216	168	181	181	181	202
Kansas	193	157	216	142	72	216	144	181	181	181	202
Delaware	105	143	70	152	174	181	196	216	216	216	221
Maryland	99	132	81	141	184	170	194	216	216	216	221
District of Columbia	103	133	75	136	184	166	189	216	216	216	221
Virginia	113	143	52	129	189	153	182	216	216	216	221
West Virginia	107	144	105	105	153	160	170	216	216	216	221
North Carolina	129	154	59	121	181	136	168	216	216	216	221
South Carolina	149	156	101	110	171	113	147	216	216	216	221
Georgia	168	159	124	96	155	101	124	216	216	216	221
Florida	208	212	155	140	191	0	141	216	216	216	221
Kentucky	119	98	136	70	122	161	144	212	212	212	221
Tennessee	140	121	138	0	119	140	123	212	212	212	202
Alabama	163	145	144	75	128	120	102	212	212	212	202
Mississippi	185	160	173	103	120	136	67	212	212	212	202
Arkansas	179	149	179	97	85	165	98	189	189	189	202
Louisiana	216	180	189	123	130	141	0	196	196	189	180
Oklahoma	216	170	216	138	79	216	126	196	196	181	202
Texas	216	212	216	146	110	186	108	196	196	181	180
Montana	216	212	216	212	196	216	196	150	165	181	221
Idaho	216	212	216	212	196	216	196	120	110	142	221
Wyoming	216	194	216	212	196	216	196	181	181	181	221
Colorado	216	192	216	193	139	216	194	181	181	181	202
New Mexico	216	212	216	212	145	216	196	196	196	181	180
Arizona	216	212	216	212	196	216	176	157	157	138	180
Utah	216	212	216	212	196	216	176	162	152	153	202
Nevada	216	212	216	212	196	216	196	145	118	92	202
Washington	216	212	216	212	196	216	196	0	79	164	221
Oregon	216	212	216	212	196	216	196	79	0	139	221
California	216	212	216	212	196	216	176	179	152	74	180

a/ Gross transportation costs, based on mileages of Table 5.1, obtained as follows:

for distances from zero to 415 miles

$$\text{Log Tr C} = 0.677557 + 0.512361 \text{Log D},$$

for distances from 416 to 1,220 miles

$$\text{Tr C} = 57.776 + 0.112428 \text{D},$$

where

Tr C is the transportation cost in cents per 100 pounds, and
D is the between points distance in miles.

Gross transportation costs for distances of 1,221 or more miles are estimated from zone rates.

Estimates of interregional transportation costs applicable in 1957 are based on the mileages of Table 18 and the average rate-distance relationships described above.[1] The relationship for rail rates was derived directly from published rate-distance data. For reasons outlined earlier, the relationship for truck rates was obtained by upward adjustment of the results for 1955 by 10.8 per cent. Estimated costs computed from these results for selected interregional movements are given in Appendix Tables C and D for strawberries packed in 10-ounce cartons and 30-pound tins. As with the estimates for 1955, the costs given in these tables are based on the use of the least-cost means of shipment between any given points and they have been adjusted to indicate the cost--based on gross weight--of transporting a given net weight of product.

REGIONAL CONSUMPTION ESTIMATES

In the periods preceding and following World War II, there have been marked changes in the pattern of consumption of strawberries. During the 1920's, for example, annual consumption of fresh strawberries was at the relatively high level of 4.2 pounds per capita. Consumption dropped slightly to 3.5 pounds in the 1930's and to 2.1 pounds in the 1940's. In the 1950's, per-capita consumption of fresh berries averaged only 1.5 pounds. The decrease in consumption rates during the 1940's can be attributed largely to the disruption of production during the war period, while failure of the fresh market to recover since then can be attributed in large part to rapid growth in the consumption of frozen berries.

Trends in annual per-capita consumption of strawberries in the postwar period are shown in Figure 4. The fresh market reflects variable--and slightly decreasing--per-capita consumption in the period 1946-1957. On the other hand, annual per-capita consumption of frozen strawberries shows a strong upward trend. This has been sufficient to offset the decline in per-capita consumption of fresh berries and to produce a slight upward trend--averaging 0.05 pounds per year--in total per-capita consumption. Despite this gain, total per-capita consumption was only 3.0 pounds in 1957--less than three-fourths as much as the average for the period 1920-1929.

1/ The "average" rate-distance relationship for rail transport rather than zone rates was used in estimating 1957 rail rates in order to facilitate analysis in a later section. The same general relationships, however, are reflected in either formulation.

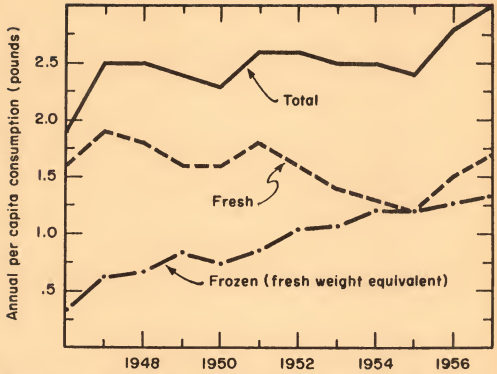


Figure 4. Per-capita consumption of strawberries in the United States; total, fresh, and frozen, 1946-1957.

Source: U. S. Agricultural Marketing Service, Consumption of Food in the United States, 1909-52 (Washington: Govt. Print. Off.) (Agriculture Handbook No. 62.) Also Supplements for the years 1955, 1956, and 1958.

The changes in per-capita consumption described above suggest the importance of determining how regional consumption is affected by variation in the prices of frozen strawberries and the products consumers consider close substitutes for them as well as evaluating the effects of other factors--for example, growth in the availability of frozen foods. Development of this type of estimate was, however, beyond the resources of this study, and so a substitute was sought in terms of estimates of regional consumption in a given year. These are useful in testing the efficiency with which the produced supply of a past period was distributed. And, when adjusted for projected changes in regional population, they contribute to consideration of the efficient location of production in future periods.

Consuming Region Composition

The refinement of results through increased subdivision of the total consuming region is limited by the availability of suitable data regarding each subdivision and by the practical need to restrict computations to a minimum level consistent with obtaining useful results. Bureau of the Census population estimates are available by states, and per-capita consumption estimates can be developed for regions comprised of several states. Application of the regional per-capita consumption estimate to each of the states included in a given region enables estimation of total consumption for each state. This results in a problem of reasonable size and is within the limits of available consumption information. Each of the mainland states and the District of Columbia are, therefore, taken as consuming regions.

Regional Consumption Estimation

This section presents estimates of total regional consumption in 1955, a recent year for which the best information is available. Projections also are given of regional consumption in 1970, a year far enough in the future to be of interest with respect to possible shifts in the location of production. The consumption figures for 1955 were developed from regional per-capita consumption and population estimates for that year, while those for 1970 are based on 1955 per-capita consumption and regional population projections for 1970. Two categories of consumption were considered, described here as "retail" and "large size." Retail consumption is defined as including all frozen strawberries packed in containers of 20 ounces net weight or less. The large-size category includes

all frozen strawberries packed in containers of more than 20 ounces net weight and so includes all institutional and manufacturing packs. Most of the large-size pack is in containers of 30 pounds or more, net weight.

Regional Per-Capita Consumption

Estimates of per-capita consumption in households are available for 1955 with respect to rather broadly defined regions, and these are used as a basis for estimating consumption in the retail category. Similar information is not available, however, in regard to consumption in the large-size category, and so it was necessary to develop rough approximations of regional consumption by indirect means. The basis for the regional per-capita consumption figures used is as follows.

Retail Per-Capita Consumption.--Estimates of regional per-capita consumption in the retail category are based on data obtained in a survey of households with respect to the consumption of frozen fruits and vegetables in 1955.[1/] The results relating to frozen strawberry consumption, given in Table 5, indicate considerable variation among regions in the consumption of frozen strawberries per household member. However, these figures cannot be applied directly to regional population to estimate regional consumption but must be adjusted to allow for nonhousehold members in the regional population totals.

The first step in adjustment of the regional per-capita figure per household member was to determine total per-capita consumption for the United States in 1955. This required consideration of alternative estimates of total pack made by the National Association of Frozen Food Processors and the U. S. Department of Agriculture. These estimates do not differ greatly, and both are presumed to be equally reliable. The Department of Agriculture estimate of a total 1955 pack of 276,179,680 pounds was selected to maintain consistency in source with respect to other estimates used in this study.[2/]

1/ The information used in this study consists of preliminary results based on U. S. Department of Agriculture data obtained under contract with the Market Research Corporation of America. These data have since been published. See Reese, Robert B., Family Purchases of Selected Frozen Fruits and Vegetables, 1955 (Washington: Govt. Print. Off., 1959). (U. S. Department of Agriculture Marketing Research Report No. 317.)

2/ U. S. Agricultural Marketing Service, Fruit and Vegetable Division, Marketing California Strawberries, 1957 Season (San Francisco: Federal-State Market News Service, May, 1958), p. 30, Table 19.

TABLE 5

Consumption Per Household Member and Per Capita of Frozen Strawberries from Retail-Size Containers

Region	Consumption per household member	Consumption per capita[a/]
	1	2
	pounds per year	
New England and Middle Atlantic	1.035	0.96433
East North Central	0.968	0.90190
West North Central	0.899	0.83762
South Atlantic and East South Central	0.543	0.50779
West South Central	0.458	0.42673
Mountain and Pacific	0.500	0.45686
United States	0.768	0.72085

a/ Regional per-capita consumption per household member reduced approximately 6.83 per cent to equate estimated consumption and disappearance.

Source:

Col. 1: Preliminary data from a survey conducted by the Market Research Corporation under contract with the U. S. Agricultural Marketing Service. These data, rounded to two decimals, have since been published in Reese, Robert B., Family Purchases of Selected Frozen Fruits and Vegetables, 1955 (Washington: Govt. Print. Off., 1959), p. 83. (U. S. Department of Agriculture Marketing Research Report No. 317.)

To obtain total consumption, the figure for total pack must be decreased by 29,791,000 pounds to allow for the increase in cold storage stocks during 1955; and it must be increased by 13,000,000 pounds to account for Mexican imports in 1955.[1] Using the adjusted total and a 1955 population figure of 164,303,000, annual per-capita consumption in all forms was estimated as 1.5787 pounds.[2/3] Total per-capita consumption was divided into the "retail" and "large size" categories on the basis of pack statistics indicating that 45.66 per cent of the strawberries frozen in 1955 were packed in cartons of 20 ounces net weight or less.[4] On this basis, consumption in retail containers in 1955 was estimated as 0.7208 pounds per capita.

The estimate developed above on the basis of aggregate industry data differs by a small amount from consumption per household member as given in Table 5. The ratio of the two estimates (0.7208/0.768) was used to adjust the regional estimates per household member to regional per-capita consumption. The adjusted figures are given in Table 5.

Consumption Per Capita--Large Size.--As defined above, this category includes all frozen strawberries packed in containers of more than 20 ounces net weight. Several studies have been made of this segment of the market, but none have been sufficiently directed toward the regional aspect to permit differentiation of consumption by regions. Consumption estimates by region for this category were, therefore, made on the basis of a national per-capita consumption estimate adjusted by means of indices to indicate regional consumption.

The basic estimate--1955 national per-capita consumption in large-size containers--was obtained by applying to total per-capita consumption, as computed above, the percentage (54.34) of total product packed in large-size containers in 1955.[5] With a total per-capita consumption of 1.5787 pounds, this yields an

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1/ Ibid., p. 31, Table 22.

2/ Population estimate from U. S. Bureau of the Census, Current Population Report (Washington: Govt. Print. Off., August 9, 1957), 16p. (U. S. Department of Commerce Series P-25, No. 160.)

3/ If the alternative estimate of total pack published by the National Association of Frozen Food Processors is used (272,179,000 pounds), total per-capita consumption in 1955 becomes 1.5592 pounds. For pack estimate, see National Association of Frozen Food Packers, Frozen Food Statistics, 1957: Part 1--Fruit (Washington, D. C.: March 31, 1958), p. 20.

4/ Ibid., p. 20.

5/ Pack percentage as given in Ibid., p. 20.

estimate of 0.85788 pounds per capita in the large-size category. Regional differentiation with respect to the national average was developed along lines presented in Table 6. Column 1 of this table defines six broad regions. Column 2 gives an index of regional consumption of frozen strawberries in the manufacture of ice cream. The index represents per-capita consumption in each region as a percentage of the national average. These regional percentages were obtained from the U. S. Department of Agriculture food consumption survey of 1955. The estimates were assumed to represent the regional relationships in the use of strawberries in ice cream. They were adjusted to show the use of frozen strawberries for this purpose on the basis of percentages given in an earlier study which reports the use of frozen fruits and berries in the ice cream industry.[1/] Similarly, an index of regional consumption of strawberries in the preserve industry was developed.[2/] This index is given in column 3 of Table 6. Column 4 of Table 6 gives a weighted index for large-size container use by regions. These are obtained by applying a weight of 0.444 to the regional index of use in ice cream manufacture and a weight of 0.556 to the regional index of use in the manufacture of preserves. The ratio applied to the preserves index is the estimated proportion of large-size pack consumed in this category.[3/] The regional distribution of the remaining proportion (0.444) is assumed to follow the pattern of the index computed for use of frozen strawberries in ice cream manufacture.

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TABLE 6

Regional Per-Capita Consumption of Frozen Strawberries
Packed in Large-Size Containers

Region	Ice cream per-capita consumption index[a]	Preserves per-capita consumption index[b]	Weighted large-size container use index[c]	Per-capita consumption pounds per year[d]	Adjusted per-capita consumption pounds per year[e]
New England and Middle Atlantic	102.04	83.19	91.599	.78547	.78199
East North Central	114.52	100.50	106.725	.91558	.91152
West North Central	110.75	100.50	105.051	.90122	.89722
South Atlantic	72.38	105.49	90.789	.77887	.77541
East South Central and West South Central	53.20	105.49	82.273	.70580	.70268
Mountain and Pacific	126.95	142.60	135.651	1.16373	1.15857
United States	100.00	100.00	100.00	.85788	.85788

a/ Per-capita consumption of ice cream obtained from U. S. Agricultural Marketing Service and U. S. Agricultural Research Service, Food Consumption of Households in the United States (Washington: Govt. Print. Off., December, 1956), p. 36, Table 6 (all urbanizations). Percentages of strawberries frozen before use in ice cream taken from U. S. Department of Agriculture, Distribution of Cold Pack Fruits and Berries to Bulk Users, 1953 (Washington: Govt. Print. Off., March, 1955), p. 7, Table 6. Based on an address by Dr. H. Wayne Bitting to the National Association of Frozen Food Packers Convention, Chicago, Illinois, March 15, 1955.

b/ U. S. Department of Agriculture, Food Consumption. . ., p. 97, Table 12 (all urbanizations).

c/ Weighted average of ice cream and preserves indices. Preserves weighting of 0.556 based on use by preservers of frozen strawberries packed in large-size containers in 1953 as given in U. S. Department of Agriculture, Distribution of Cold Pack Fruits. . ., p. 4, Table 3.

d/ Weighted "large size container" use index applied to United States per-capita consumption of frozen strawberries packed in large-size containers.

e/ Regional per-capita consumption decreased 0.44314 per cent to equate calculated consumption and calculated disappearance for 1955.

The resulting weighted regional indices, applied to the national average consumption per capita, give the estimates of regional per-capita consumption shown in column 5 of Table 6. The final column of the table adjusts the regional per-capita consumption figures of column 5 downward by 0.4434 per cent to equate calculated consumption and calculated disappearance.

Population

State population estimates are taken from the U. S. Bureau of the Census estimates, Series P-25, No. 160,[1] and the single estimate given is used for 1955. Four estimates of 1970 population are given in this series based on different assumptions with respect to birth rate, death rate, and migration. In this study, the upper and lower extremes are avoided, and an average of the remaining two estimates is used. These population estimates are given in Table 7 for the years 1955 and 1970.

Regional Consumption

As discussed in previous sections, per-capita consumption calculations are based on 1955 estimates of production and population and are adjusted to equate calculated consumption and disappearance for that year. Regional per-capita consumption is calculated for broad regions, and state consumption is based on state population and per-capita consumption of the region in which that state is located. Consumption in 1970 is estimated using these 1955 per-capita consumption estimates and the 1970 population estimate described above. Table 8 gives estimated state consumption of strawberries from retail and large-size containers in the years 1955 and 1970.

LOCATION OF FROZEN STRAWBERRY PRODUCTION

Regional frozen strawberry production and transfer costs and the demands of the various consuming regions determine the pattern of production location and interregional trade flows in this commodity. The remainder of this report is devoted to an analysis of these relationships. A preliminary view of this problem can be obtained, however, by brief review of the cost relationships

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1/ U. S. Bureau of the Census, op. cit.

TABLE 7

Total Population Estimates by States, 1955 and 1970

State	1955	1970	State	1955	1970
	thousands			thousands	
Maine	906	1,012	Virginia	3,579	4,455.5
New Hampshire	553	647	West Virginia	1,984	2,134.5
Vermont	370	398.5	North Carolina	4,344	5,148
Massachusetts	4,773	5,500.5	South Carolina	2,308	2,733.5
Rhode Island	817	924.5	Georgia	3,662	4,228.5
Connecticut	2,200	2,787	Florida	3,580	5,411
New York	16,021	19,399.5	Kentucky	3,011	3,124.5
New Jersey	5,324	6,679.5	Tennessee	3,414	3,978
Pennsylvania	10,898	12,384	Alabama	3,110	3,401
Ohio	8,945	11,533	Mississippi	2,133	2,179.5
Indiana	4,329	5,528	Arkansas	1,802	1,634.5
Illinois	9,301	11,097.5	Louisiana	2,934	3,639
Michigan	7,326	9,921	Oklahoma	2,210	2,083
Wisconsin	3,702	4,468	Texas	8,748	11,278.5
Minnesota	3,190	3,765.5	Montana	629	739
Iowa	2,671	2,911	Idaho	612	749
Missouri	4,201	4,756.5	Wyoming	312	389
North Dakota	643	662.5	Colorado	1,574	2,049
South Dakota	683	737.5	New Mexico	793	1,114.5
Nebraska	1,394	1,505.5	Arizona	1,007	1,614
Kansas	2,060	2,353	Utah	797	1,098
Delaware	390	545	Nevada	235	385
Maryland	2,744	3,802	Washington	2,607	3,569
District of Columbia	857	1,058.5	Oregon	1,685	2,409
			California	12,961	19,679

TABLE 8

Estimated Strawberry Consumption by State: 1955 and 1970

State	1955		1970	
	Retail-size containers[a]	Large containers[b]	Retail-size containers[a]	Large containers[b]
	pounds per year			
Maine	873,683	708,481	975,902	791,372
New Hampshire	533,274	432,439	623,932	505,946
Vermont	356,802	289,336	384,286	311,622
Massachusetts	4,602,747	3,732,428	5,304,297	4,301,324
Rhode Island	787,858	638,884	891,523	722,948
Connecticut	2,131,526	1,720,373	2,687,588	2,179,400
New York	15,449,532	12,528,228	18,707,520	15,170,174
New Jersey	5,134,093	4,163,304	6,441,242	5,223,288
Pennsylvania	10,509,269	8,522,104	11,942,263	9,684,138
Ohio	8,067,538	8,153,527	10,401,668	10,512,535
Indiana	3,904,346	3,945,961	4,985,730	5,038,871
Illinois	8,388,617	8,478,027	10,008,888	10,115,569
Michigan	6,607,354	6,677,780	8,947,797	9,043,168
Wisconsin	3,338,851	3,774,439	4,029,711	4,072,662
Minnesota	2,671,995	2,862,133	3,154,043	3,378,484
Iowa	2,237,273	2,396,476	2,438,300	2,611,809
Missouri	3,518,825	3,769,223	3,984,121	4,267,629
North Dakota	538,587	576,913	554,921	594,409
South Dakota	572,092	612,802	617,742	661,700
Nebraska	1,167,637	1,250,725	1,261,031	1,350,765
Kansas	1,725,489	1,848,274	1,970,911	2,111,160
Delaware	198,037	302,410	276,744	422,599
Maryland	1,393,368	2,127,729	1,930,607	2,948,114
District of Columbia	435,174	664,528	537,493	820,773
Virginia	1,817,371	2,775,198	2,262,446	3,454,846
West Virginia	1,007,450	1,538,416	1,083,872	1,655,116
North Carolina	2,205,828	3,368,387	2,614,089	3,991,818
South Carolina	1,171,973	1,789,650	1,388,037	2,119,587
Georgia	1,859,517	2,839,557	2,147,179	3,278,827
Florida	1,817,878	2,775,973	2,747,637	4,195,752
Kentucky	1,528,948	2,115,763	1,586,581	2,195,517
Tennessee	1,733,586	2,398,943	2,019,978	2,795,253
Alabama	1,579,218	2,185,328	1,726,985	2,389,808
Mississippi	1,083,110	1,498,812	1,106,722	1,531,487
Arkansas	768,963	1,266,226	697,486	1,148,527
Louisiana	1,252,019	2,061,657	1,552,862	2,557,045
Oklahoma	943,068	1,552,918	888,874	1,463,678
Texas	3,733,014	6,147,027	4,812,848	7,925,153
Montana	293,026	728,740	337,619	856,183
Idaho	285,106	709,044	342,188	867,768
Wyoming	145,348	361,474	176,805	448,366
Colorado	720,685	1,792,307	936,106	2,373,908
New Mexico	369,427	918,745	509,170	1,291,225
Arizona	469,121	1,166,679	737,372	1,869,931
Utah	371,290	923,380	501,632	1,272,109
Nevada	109,477	272,264	175,891	446,049
Washington	1,214,497	3,020,390	1,630,533	4,134,934
Oregon	784,974	1,952,189	1,100,575	2,790,993
California	6,038,010	15,016,216	8,990,546	22,799,484

a/ Includes all containers of 20 ounces or less, net weight.

b/ Includes all containers of more than 20 ounces, net weight.

developed thus far. This is done in Table 9, which demonstrates the ability of the region of largest output (Region 10, California) to compete with frozen strawberries produced locally in each of the remaining producing regions.

The first step in developing these comparisons is to compute, for each producing region, the delivered cost of California frozen strawberries at the consuming center nearest the center of production in each region. Regarding Region 1, for example, this consists of California at-plant total unit cost, plus transportation costs to Albany, New York, the consuming center nearest the producing area of Region 1. This is shown in Table 9 to be 21.57 cents per processed pound. The competitive "raw product value" for local producers, then, is estimated by subtracting from the California delivered cost the cost of transportation between local consuming and producing centers and the processing costs applicable to the local region. In the above example, this involves the deduction of 1.11 cents per pound for transportation and 11.05 cents per pound for processing, leaving 9.41 cents per pound as the competitive "product value" facing local producers on the basis of California production and transfer costs into Region 1. These values for the ten producing regions are given for both 10-ounce cartons and 30-pound tins in column 6 of the table, where they are described as "imputed values."

The imputed values for processed product given in Table 9 must, however, be adjusted for the amount of culls removed and sugar added in processing in order to make them comparable with local farm production costs. The adjusted values--giving the imputed local values per pound of raw (farm) output--are given in column 7 of the table.

Comparison of the local imputed values of raw product (as related to Region 10 delivered costs) with local farm production costs indicates the capability of local producers in competing with shipments from Region 10. For example, the imputed value of raw product in Region 1 is 10.8 cents per pound as compared with estimated local farm production costs of 13.8 cents per pound. This indicates that Region 1 berries cannot compete on a price basis with frozen berries shipped from Region 10. Similarly, local farm production costs are substantially higher than the imputed value of local raw product in Regions 3, 5, 6, and 7. These regions also appear unable to compete--in the consuming region nearest their producing areas--with inshipments from Region 10. In Regions 2 and 4, local farm production costs are only slightly higher than the imputed values in these regions (relative to Region 10 output), while farm production costs are significantly lower than imputed values in Regions 8 and 9. This means that Region 10 (California) has only a narrow advantage in Regions 2 and 4 and is at a competitive disadvantage in Regions 8 and 9.

TABLE 9

Imputed Value of Local Regional Production, Based on Delivered Cost of California Frozen Strawberries, 1958

Producing region and type of container	Selected geographic centers: Production	Selected geographic centers: Consumption	Delivered cost of California strawberries[a]	Local nonfarm costs: Transportation[b]	Local nonfarm costs: Processing[c]	Local imputed values of: processed product[d]	Local imputed values of: raw product[e]	Local farm production cost[f]
	1	2	3	4	5	6	7	8
			cents per pound					
10-ounce cartons								
1	Buffalo New York	Albany New York	21.57	1.11	11.05	9.41	10.6	13.8
2	Manistee Michigan	Lansing Michigan	21.46	.65	11.03	9.78	11.0	11.5
3	Norfolk Virginia	Richmond Virginia	21.54	.67	11.31	9.56	10.8	12.6
4	Nashville Tennessee	Nashville Tennessee	21.44	--[g]	11.45	9.99	11.2	11.6
5	Joplin Missouri	Little Rock Arkansas	21.38	1.10	11.83	8.45	9.5	16.7
6	Tampa Florida	Tampa Florida	21.52	--	12.51	9.01	10.1	25.1
7	Baton Rouge Louisiana	Baton Rouge Louisiana	21.40	--	12.23	9.17	10.3	23.1
8	Seattle Washington	Seattle Washington	20.88	--	11.03	9.85	11.1	9.5
9	Salem Oregon	Salem Oregon	20.53	--	11.02	9.51	10.7	9.7
10	Salinas California	Bakersfield California	19.69	.96	10.20	8.53	9.6	9.6
30-pound tins								
1	Buffalo New York	Albany New York	17.29	1.02	6.56	9.71	10.9	13.8
2	Manistee Michigan	Lansing Michigan	17.20	.59	6.44	10.17	11.4	11.5
3	Norfolk Virginia	Richmond Virginia	17.27	.62	6.64	10.01	11.3	12.6
4	Nashville Tennessee	Nashville Tennessee	17.17	--	6.79	10.38	11.7	11.6
5	Joplin Missouri	Little Rock Arkansas	17.12	1.01	7.07	9.04	10.2	16.7
6	Tampa Florida	Tampa Florida	17.25	--	7.75	9.50	10.7	25.1
7	Baton Rouge Louisiana	Baton Rouge Louisiana	17.14	--	7.50	9.64	10.8	23.1
8	Seattle Washington	Seattle Washington	16.66	--	6.51	10.15	11.4	9.5
9	Salem Oregon	Salem Oregon	16.34	--	6.51	9.83	11.1	9.7
10	Salinas California	Bakersfield California	15.58	.88	6.17	8.53	9.6	9.6

a/ Region 10 total at-plant costs (from Table 2) plus transportation costs to selected geographic centers (from Appendix Tables C and D). Plant sizes on which regional at-plant costs are based: Regions 8, 9, 10, 25,000 pounds per hour; Regions 1 to 7, 10,000 pounds per hour.
b/ From Appendix Tables C and D.
c/ Local at-plant total costs for plant of appropriate size (Table 2) less farm production costs (Table 1) adjusted for culls removed and sugar added in processing. Adjusted farm production costs = (farm cost per pound) (1.1111)(0.80).
d/ Column (3) - column (4) - column (5).
e/ Column (6) / (1.1111)(0.80).
f/ From Table 1.
g/ Dashes indicate no interregional transfer involved and so transportation costs are not applicable.

By extension of this type of comparison, it could be shown that the competitive positions of Regions 8 and 9 relative to other producing regions are similar to that of Region 10. This means that all three regions are close competitors in the national market. Such comparisons, however, are only suggestive, as they permit consideration of the problem only on the basis of each major producing area, taken singly. An appropriate solution requires that the competitive relationships among all producing regions be considered simultaneously. This type of analysis is given below.

The more general solution makes use of the estimates of production and transfer costs developed in the preceding sections for the ten strawberry producing regions to estimate total delivered unit cost in any consuming region from any producing region. Use also is made of the estimates of consumption developed for a recent year--1955--for 49 consuming areas as well as projections of consumption in these areas in 1970. Two categories of consumption are considered: "retail," involving product packed in containers of 20 ounces or less net weight; and "large size," consisting of packs in containers exceeding 20 ounces net weight and used primarily in the manufacture of food products.

The regional cost and consumption estimates are the basis of analyses, using linear programming techniques, which develop optimal patterns of movement of the produced supply of frozen strawberries in 1955 from producing to consuming regions as well as the location of strawberry production that might be expected in the future under various alternative circumstances.

The 49 consuming regions consist of the 48 mainland states and the District of Columbia. The ten producing regions are as defined in Figure 2. Mexico, from which some frozen strawberries are imported, is also treated as a producing area, but it requires special treatment in the analysis because of the lack of production and transfer cost data pertaining to its output.

Basic Assumptions and Specifications

Analysis of the broad problem considered in this study is aided by certain simplifying assumptions and specifications. These, given below, are not unrealistic, since they retain the basic regional relationships.

1. The individual firm and, therefore, the producing region, aim to maximize profits and thus will ship to the market which yields the largest returns after deduction of transportation costs.

2. Supply and consumption areas are treated as points. Supply points are chosen near presently important producing areas. Where two or more important producing areas are located within a producing region, a point midway between these areas is chosen. Consumption points are chosen near the estimated center of the consuming region.

3. The location of ice cream consumption is assumed to coincide with the location of ice cream manufacture. This is less likely to be true of preserves and similar products. With respect to both categories, however, the analyses of interregional movements are based on the transportation cost of frozen product from producing region to point of processing.

4. Except when otherwise specified, consumers are considered to be indifferent to the source of strawberries purchased. This assumes absence of quality or other inherent characteristic differentials among the products of different regions or indifference on the part of consumers to existing quality differences.

5. The estimated costs of processing and shipping strawberries in 10-ounce and 30-pound tins are considered to be representative of regional cost relationships for all 20-ounce or less (retail-size) and over 20-ounce (large-size) containers, respectively. These particular container sizes are chosen because they represent the majority of the frozen strawberry pack.

Framework of Analysis

The analysis that follows is based on several models, each involving certain additional specifications or conditions that represent plausible possibilities of special interest. The models are designed to demonstrate the impact of regional cost relationships, as determined in this study, on production location and the probable effect of variation in their costs and in other locational determinants.

Two of the models relate to production and distribution of the quantities of frozen strawberries actually consumed in 1955. The remaining models consider future adjustments based on estimated regional consumption in 1970. With regard to both periods, consumption of each region has been estimated as a fixed quantity. Output in each producing region is, however, allowed to vary in all except the first model--1955 distribution. Determination of source of supply for each consuming region then depends on the total unit cost of supplying frozen strawberries to that region. With all except Model I, the regional production-consumption flows are determined so as to minimize the total cost of production, processing, and distribution of the total United States consumption under the conditions specified for each model.

The general characteristics of the models considered are indicated below, and this is followed by more detailed specification and results with respect to the individual models.

A. Analysis of 1955 production and distribution

Model I: Regional production and consumption are as observed in 1955. The distribution of produced supply is studied from the standpoint of minimizing total transportation cost for the entire output.

Model II: Regional consumption is as observed in 1955, but the location of its production is allowed to assume a pattern that would minimize the total cost of its production and distribution.

B. Analyses based on projected regional consumption in 1970

Model III: Regional consumption is as projected for 1970. The location of production that minimizes the total cost of producing and distributing this supply, based on the structure of costs prevailing in 1958, is determined.

Model IV: In this case, the specifications of Model III are changed only with respect to transportation costs. Several levels of increased transportation cost are considered to indicate the effect of shifts in this cost category on regional production allocations.

Model V: In this model, the assumption that buyers do not discriminate with respect to producing region in the purchase of strawberries is abandoned. The effect of this on the location of production is studied in terms of price differentials paid for the product of a given region.

Model VI: In the above, the techniques of berry production are considered fixed. Model VI is designed to show the effect of a cost-reducing technical advance in a particular region.

Model VII: The analysis to this point is based on the production and transfer cost relationships prevailing in 1957-58, or on the assumption that any changes from this level would be proportionally the same in all regions. Model VII is designed to show the effect of a differential increase in cost level in an important producing region. This is demonstrated through consideration of several levels of cost increase in Region 10, with costs in the other regions remaining at 1957-58 levels.

Model VIII: In the preceding models, per-capita consumption of frozen strawberries is assumed to remain at the 1955 level, with population growth accounting for all increased consumption in 1970 as compared with 1955. Model VIII is based on a projection to 1970 of the average rate of increase in per-capita consumption that occurred in the period 1954-1958. This amounts to an increase in 1970 regional consumption of approximately 25 per cent over that previously estimated.

Model IX: The 1970 regional consumption levels of Model VIII are retained in this model, but regional production expansion--unlimited in previous models--is restricted to 75 per cent of the average production for processing in each region for the period 1953-1957.

Analysis of 1955 Production and Distribution

Model I--1955 Distribution

The objective in the 1955 distribution model is the determination of optimal interregional flows of predetermined production and consumption quantities. Total regional production of frozen strawberries, adjusted for carry-over differential, was determined from Agricultural Marketing Service estimates.[1] These regional outputs were then divided into "retail" container and "large-size" container packs on the basis of percentages of each container size packed in each region. The percentages used were determined from state statistics furnished by the National Association of Frozen Food Packers. The statistics were given by state for major producing states and, to preserve anonymity of individual packer output, by groups of states for minor producing states. Estimates for minor regions are, therefore, less precise than for major regions. The estimated total import from Mexico was divided into the two size categories as a residual to balance estimated total production and consumption. Table 10 gives the estimated 1955 pack by container size and region.

Total consumption of frozen strawberries by container category was calculated for each state from estimated per-capita consumption and state population data.[2] Having the regional production and consumption totals, the transportation-cost-minimizing interregional flow is easily determined using the "transportation model" of linear programming. In this solution, each of the 48 states and the District of Columbia is taken as a consuming region, making a total of 49. Of the ten producing areas, Region 1 did not produce a significant quantity of frozen strawberries in 1955 and so is omitted from the analysis. The remaining nine regions, with the imports from Mexico, make a total of ten producing regions.[3]

1/ U. S. Agricultural Marketing Service, Fruit and Vegetable Division, Marketing California Strawberries, 1957 Season

2/ The procedure followed in this calculation is explained in an earlier section. Estimated state consumption quantities are given in Table 8.

3/ A linear programming transportation cost-minimizing solution should, therefore, have 58 interregional movements. The problem is set up as a matrix of 10 columns and 49 rows. The solution must have a number of entries equal to the sum of the rows and columns minus 1--in this case, 49 plus 10 minus 1.

For a nonmathematical explanation of the solution procedure, see Snodgrass, M. M., and C. E. French, "Simplified Presentation of 'Transportation-Problem Procedure' in Linear Programming," Journal of Farm Economics, vol. 39, no. 1, February, 1957, pp. 40-51.

TABLE 10

Estimated 1955 Frozen Strawberry Pack by Producing Region and Container Category

Producing region[a]	Retail-size containers	Large-size containers
	pounds	
2	577,074	10,149,211
3	545,012	545,012
4	6,104,613	10,448,025
5	430,352	736,545
6	1,426,960	1,426,960
7	1,369,675	1,369,675
8	17,084,729	16,480,554
9	42,012,260	36,339,587
10	44,863,045	54,479,392
Mexican imports	4,023,151	8,976,849
Total	118,436,871	140,951,809

a/ Region 1 did not produce a significant quantity of frozen strawberries in 1955 and so is omitted. Mexican imports are added, leaving a total of 10 regions.

Source: Total regional production of frozen strawberries is compiled from U. S. Agricultural Marketing Service, Fruit and Vegetable Division, Marketing California Strawberries, 1957 Season (San Francisco: Federal-State Market News Service, May, 1958), Table 24. The totals are divided into "retail size" and "large size" categories on the basis of pack information supplied by the National Association of Frozen Food Packers, Washington, D. C.

Transportation costs given in Appendix Tables A and B are used in this model. This incorporates in the problem the zone structure of rail transportation rates. It means that in many cases identical rates apply from two or more producing regions to a given consuming point. This is particularly true of shipments from the three western regions. There is, therefore, no single optimum solution for this problem.1/

Table 11 indicates the general nature of the transportation cost-minimizing distribution pattern for 1955. Specific export quantities are shown for the cases where shipments must be made from a specific producing region to minimize total transportation cost. For the many cases in which alternative sources of product for given regions give equal cost, the alternative producing regions and quantities exported are grouped.2/

Less than one-half of the 1955 movements are identified as originating in one specific region. This would seem seriously to limit the usefulness of the solution of the problem. However, all movements can be identified if the states of Washington, Oregon, and California are considered to be one producing region. Furthermore, it is of interest to know what movements result in an absolute transportation-cost advantage and in what areas some alternative movements are possible without transportation-cost disadvantage.

1/ This is similar in concept to the "neutral circuits" referred to in Koopmans, T. C., and Stanley Reiter, "A Model of Transportation," Activity Analysis of Production and Allocation, edited by T. C. Koopmans (New York: John Wiley and Sons, 1951), p. 253. (Cowles Commission Monograph 13.) The "neutral circuits" refer to a situation where homogeneous products destined for two receiving points pass a common point (such as a cape or narrow passage) en route to their destinations so that the cargoes could be interchanged without change in total transportation cost.

The strawberry shipments of this study do not necessarily pass a common geographic point but do pass common "transportation cost" zones, resulting in the same effect as noted by Koopmans.

2/ Because of equal transportation costs and joint listing of Regions 8, 9, and 10, the solution does not show a total of 58 interregional movements as required by the "transportation model." And the result is not strictly a "solution," since it does not completely allocate production of Regions 8, 9, and 10 to specific regions. The joint allocation signifies that any one of the large number of possible specific "solutions" which in some manner assigned the strawberries from Regions 8, 9, and 10 to the consuming regions now shown as receiving from Regions 8, 9, or 10, would result in equal total transportation costs. Any one of the possible specific solutions would require that two of the states receiving from producing Regions 8, 9, or 10 receive from two of these regions or that one consuming region receive from three producing regions. The total movements would then be 58 as required.

TABLE 11

Optimal Distribution Pattern for Frozen Strawberries Packed in Retail-Size and Large-Size Containers, 1955

Retail size			Large size		
	Distribution			Distribution	
Producing region[a/]	Consuming region	Amount	Producing region[a/]	Consuming region	Amount
		pounds			pounds
2	Michigan	577,074	2	Ohio	3,273,481
				Indiana	197,970
				Michigan	8,677,780
3	Virginia	545,012	3	Virginia	545,012
4	Indiana	1,262,861	4	Indiana	3,747,991
	Kentucky	1,528,948		Kentucky	2,115,763
	Tennessee	1,733,588		Tennessee	2,398,943
	Alabama	1,579,218		Alabama	2,185,328
5	Missouri	430,352	5	Arkansas	736,545
6	Florida	1,428,980	6	Florida	1,426,960
7	Mississippi	117,658	7	Louisiana	1,389,764
	Louisiana	1,252,019			
8	Montana	293,026	8	Montana	728,740
	Washington	1,214,479		Washington	3,020,390
9	Idaho	285,106	9	Idaho	709,044
	Utah	371,290		Utah	923,380
	Oregon	784,974		Oregon	1,952,189
10	New Mexico	369,427	10	Oklahoma	1,443,572
	Arizona	469,121		New Mexico	918,475
	Nevada	109,477		Arizona	1,168,679
	California	8,038,010		Nevada	272,264
				California	15,016,218
8 or 9	Minnesota	2,871,995	8 or 9	Minnesota	2,882,133
8, 9, or 10	Maine	873,683	8, 9, or 10	Maine	708,481
	New Hampshire	533,574		New Hampshire	432,439
	Vermont	356,802		Vermont	289,336
	Massachusetts	4,802,747		Massachusetts	3,732,428
	Rhode Island	787,858		Rhode Island	638,884
	Connecticut	2,121,526		Connecticut	1,720,373
	New York	15,449,532		New York	12,528,229
	New Jersey	5,134,093		New Jersey	4,163,304
	Pennsylvania	10,509,269		Pennsylvania	8,522,106
	Ohio	8,067,538		Ohio	8,163,527
	Indiana	2,641,485		Illinois	8,478,027
	Illinois	8,388,617		Wisconsin	3,374,439
	Michigan	6,030,280		Iowa	2,398,476
	Wisconsin	3,338,881		Missouri	3,769,223
	Iowa	2,237,273		North Dakota	576,913
	Missouri	3,088,473		South Dakota	612,802
	North Dakota	538,587		Nebraska	1,250,725
	South Dakota	572,092		Kansas	1,848,274
	Nebraska	1,167,637		Delaware	302,410
	Kansas	1,725,489		Maryland	2,127,729
	Delaware	198,037		District of Columbia	664,528
	Maryland	1,393,368		Virginia	2,220,106
	District of Columbia	435,174		West Virginia	1,638,418
	Virginia	1,272,359		North Carolina	3,368,387
	West Virginia	1,007,450		South Carolina	1,789,650
	North Carolina	2,205,828		Georgia	2,639,557
	South Carolina	1,171,973		Florida	1,349,013
	Georgia	1,889,617		Wyoming	448,366
	Florida	390,918		Colorado	2,373,908
	Mississippi	875,317			
	Arkansas	768,963			
	Oklahoma	943,068			
	Wyoming	145,348			
	Colorado	720,686			
Mexico	Texas	3,733,014	Mexico	Mississippi	1,498,812
	Mississippi	290,137		Arkansas	529,681
				Louisiana	691,983
				Oklahoma	109,348
				Texas	8,147,027

a/ Region 1 did not produce a significant quantity of frozen strawberries in 1955 and so is omitted. Mexican imports are added, leaving a total of 10 regions.

Figures 5 and 6 show the market areas of the supply regions as given in Table 11. In these figures, the specific sources of supply--the producing regions--are identified by number in each consuming state. The shading indicates areas to be supplied by Regions 8, 9, or 10. It is interesting to note the shape of the market areas of the various producing regions. The minor producing regions dispose of their product in immediately adjacent consuming regions. Regions having somewhat greater production than is consumed in the immediate vicinity, supply adjoining areas. The Region 2 and Mexican large-size container supply areas are of the shape expected from theoretical considerations, with the area extending eastward from the producing region, away from major exporting regions. The Region 4 supply area, however, does not appear on the maps to have the shape one would expect. This region would be expected to supply to the east rather than to the north and south. The explanation lies in the transportation rate structure and the difference in location of geographical and population centers of a state. In the rate structure from the western regions, the same transportation rate applies over much of the eastern part of the United States. Short-haul transportation cost from eastern producing areas, on the other hand, increases continuously with distance, and so the minor eastern producing regions tend to supply the nearest consuming "points" regardless of direction. The consuming "point" nearest the producing "point" of Region 4 is in Tennessee, so Region 4 supplies Tennessee. The consuming points following in distance from Region 4 are Kentucky, Alabama, and Indiana, so the balance of Region 4 production goes to these states.

Model II--1955 Total Cost

Model I presents the efficient distribution pattern with the given regional supplies and consumptions of 1955. Model II is designed to determine the production location and export-import pattern for 1955 regional consumption, assuming an adjustment that would have minimized the total cost of its production, processing, and shipping. Comparison of this result and that of Model I provides a measure of the efficiency of the actual pattern of production and distribution in 1955.

Total estimated delivered costs are based on 1955 transportation rates and the 1958 processed product costs of Table 2. The nonshipping costs are thus based on 1958 conditions, resulting in an upward bias in total cost and a disproportionately high weighting of nonshipping costs. This, however, only strengthens the conclusions reached as a result of this model.

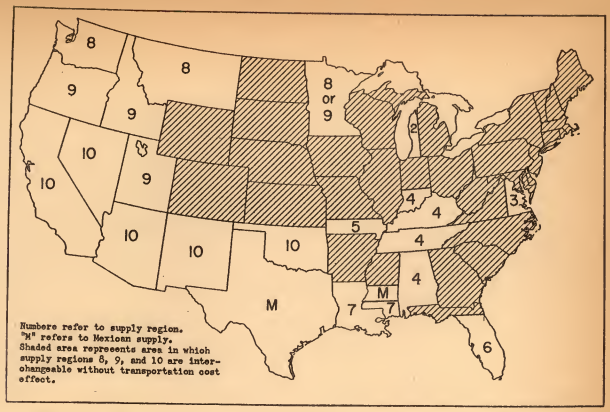

Figure 5. Optimal distribution pattern for frozen strawberries packed in retail-size containers, 1955.

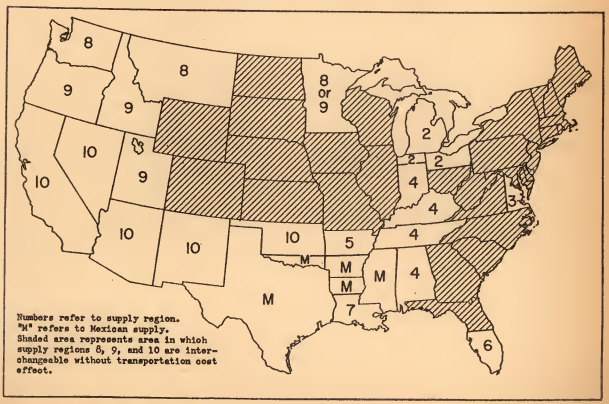

Figure 6. Optimal distribution pattern for frozen strawberries packed in large-size containers, 1955.

Total cost determines the location of production in this model. The consumption needs of each region are filled by the producing region which could have produced, processed, and shipped to that region at the lowest total cost. It is assumed that any processing region could expand production to supply all consuming regions if necessary. Under these assumptions, the solution indicates that because of its lower producing and processing costs, Region 10 would have produced all of the United States frozen strawberries except the quantities consumed in Washington and Oregon. The Mexican imports, retained at the previously given amounts, would have gone to the states of Texas and Louisiana.

Efficiency of the 1955 Production Pattern.--Comparison of the total cost of production, processing, and shipping resulting from the given production locations of Model I and the "efficient" production locations of Model II provides an indication of the effeciency of the production pattern existing in 1955. Mexican production and processing unit costs are assumed to be equal to Region 10 unit costs for the purpose of this comparison. In Model I, the total cost of production, processing, and distribution, with efficient distribution of the existing supply, would have been about $24,084,000. This same cost calculated under Model II, involving both efficient distribution and production (least total cost), would have been approximately $23,455,000. The difference is only about $629,000 (2.6 per cent of the total cost) and in these terms good adjustment is indicated in the frozen strawberry industry with respect to location of production in 1955.

When the difference in production location is given on a pounds produced basis, however, the industry does not appear to be so well adjusted. In 1955, Region 10 produced nearly 100,000,000 pounds of frozen strawberries--38 per cent of the total United States consumption. If production had been in long-run equilibrium in accordance with Model II, Region 10 would have produced nearly 240,000,000 pounds--92 per cent of the total United States consumption. This considerable difference would seem to indicate a great divergence between actual and long-run equilibrium production locations.

The reason for the apparently conflicting conclusions to be drawn from the comparisons on cost and poundage bases is apparent from the production cost figures of the regions actually producing in 1955. For instance, Regions 8 and 9 were important producers of strawberries for processing in 1955. The estimated total processed product cost in these regions is only slightly higher than that of Region 10. Regions 8, 9, and 10 produced more than 82 per cent of the frozen strawberries consumed in the United States in 1955. The 1955 production given by this model would, therefore, transfer less than 11 per cent of the total United

States consumption into Region 10 from eastern regions. Since the total delivered costs of frozen strawberries in eastern markets are only a little higher for berries from eastern than from western producing regions, the per-unit cost saving would be very small, and so very large shifts in regional output would yield small savings in total cost. In terms of potential savings, therefore, the industry appears to approximate fairly well an optimum production-distribution pattern.

Analyses Based on Projected Regional Consumption in 1970

The analyses based on projected regional consumption in 1970 indicate the location of production that minimizes total cost of production and distribution under the conditions specified in particular models and using costs for the 1957-58 period. This implies that costs will not change between 1957-58 and 1970. The results will, of course, be in error if changes in the relationships among cost components are large enough to change the production allocation for at least one consuming region.[1/] Certain types of cost changes, however, could occur without invalidating the analysis. This is true, for example, if the cost relationships remain unchanged; that is, if all costs change by the same percentage.

In first approximations to a production-consumption balance in each of the following models, the processing cost used is that applicable to plants of 25,000 pounds per hour capacity rate. If any regions were allocated a very small quantity through this initial calculation, their processing costs were adjusted upward to the level of plants of 10,000 pounds per hour capacity. The previously determined production-consumption balance was then adjusted to conform with the revised cost structure.

Mexican production and processing costs are not known, and so Mexican imports cannot be estimated on a long-run basis. Imports from Mexico were assumed to remain at the 1955 level and were allocated to consuming regions on the basis of minimizing transportation cost.

1/ The effect of relative cost-component change is demonstrated in Model IV, where assumptions as to possible future changes in transportation rates--other costs remaining unchanged--are studied with respect to their effect on regional production allocations.

Model III--1970 Unrestricted Total Cost

In this model, based on estimated 1970 consumption, the only determinant of production location is cost. The region which can produce, process, and ship the product to any consuming area at the lowest total cost will supply all of that market.

Production costs of Regions 8, 9, and 10 are approximately equal. These regions also are about the same distance from the other major consuming markets, and so transportation costs are approximately equal. Although processing costs are not a large part of the total cost where all other costs are nearly equal--as in this case--small differences in processing costs are sufficient to allocate large quantities of production. Region 10 processing costs are lowest of all regions for both container categories, giving this region a total cost advantage over Regions 8 and 9 in production for consumption outside these regions. Region 10 has a transportation cost disadvantage with respect to all regions other than 8 or 9 when shipping to eastern markets.

Because regions which have only slightly higher at-plant processed product cost than Region 10 have equally high transportation costs, and regions of comparatively low transportation cost have high at-plant processed product costs, Region 10 has a total-cost advantage over most of the United States. Therefore, on a least-total-cost basis, Region 10 would supply all of the estimated 1970 consumption of frozen strawberries in the United States with only four exceptions: Washington would be supplied by Region 8; Oregon by Region 9; Tennessee (large-size containers only) by Region 4; and Mexican imports, assumed to continue at the 1955 level, would be absorbed primarily by Texas. The remainder of United States consumption--nearly 300,000,000 pounds and 93 per cent of the total would be produced in Region 10.

Model IV--1970 Unrestricted Total Cost With Transportation Rate Increase

With transportation cost an important part of delivered cost in consuming markets--especially for West Coast production--the total-cost advantage demonstrated above for Region 10 (California) may be adversely affected by increased transportation cost. Model IV, therefore, considers the effects of increased transportation cost at several levels. The results show that rather large changes in the general level of transportation costs are required to produce substantial changes in the production location pattern.

If, for instance, rates from all regions were increased 10 per cent, the only change would be that Region 2 could then produce in large-size containers at lowest total cost for the states of Michigan and Illinois. This would cause

an increase in Region 2 production from zero to 19,000,000 pounds. If the transportation rates were increased 20 per cent, Region 2 production would increase to nearly 44,000,000 pounds as a result of becoming the region of least total-cost production for Ohio and Indiana large-size containers and for Michigan retail containers. Region 4 would assume production of retail containers for Tennessee. At a transportation rate increase of 30 per cent, Region 2 would increase total production to about 58,000,000 pounds, and at a 40 per cent transportation rate increase, it would expand to more than 73,000,000 pounds. If rates increased 50 per cent, Region 2 would become the least-total-cost producing region--for both retail and large-size containers--for the five comparatively populous states of Illinois, Indiana, Ohio, Michigan, and Wisconsin.

Table 12 shows the estimated 1970 production-consumption balance that would result with a 50 per cent rate increase. Region 4 production is 2,000,000 pounds greater than under 1957 transportation rates. Region 2 would receive the most benefit from the transportation rate increase, since production would increase from zero to over 77,000,000 pounds--24 per cent of total United States consumption. All of the gains of Regions 2 and 4 would represent reductions in Region 10 production, which would decrease from 93 to 67 per cent of United States consumption.

The production allocations determined above on the basis of uniform transportation rate increases among regions would be quite different if relatively larger rate adjustments were to occur in given regions. The competitive advantage of regions experiencing the relatively higher transportation cost would, of course, be reduced.

Model V--1970 Total Cost With Regional Price Differentials

Whether there are inherent quality differences in strawberries produced in different regions for which consumers are willing to pay could be determined only through a demand analysis which considered strawberries of different origins to be different products. Such an analysis has not been made.

It is generally agreed among industry representatives that consumers do not have a measurable preference for strawberries of specific regional origin. The proponents of differential pricing by region argue that this is because consumers have not been given the opportunity to know the origin of frozen strawberries and thereby to associate quality and region. Quality and brand are considered more likely to be associated. If there were significant differences in quality, it would seem that "best quality" brands would seek the product of "best quality" regions and be willing to pay a premium for that product. If this condition exists in the present market, it is only to a limited extent.

TABLE 12

Estimated 1970 Production-Consumption Balance for Frozen Strawberries Packed in Retail-Size and Large-Size Containers, With Transportation Rates 50 Per Cent Higher Than in 1957[a]

Retail size			Large size		
Distribution			Distribution		
Producing region[b]	Consuming region	Amount	Producing region[b]	Consuming region	Amount
		pounds			pounds
2	Ohio	10,401,668	2	Ohio	10,512,535
	Indiana	4,985,730		Indiana	5,038,871
	Illinois	10,008,888		Illinois	10,115,569
	Michigan	8,947,797		Michigan	9,043,168
	Wisconsin	4,029,711		Wisconsin	4,072,662
4	Tennessee	2,019,978	4	Tennessee	2,795,253
8	Montana	337,619	8	Montana	856,183
	Washington	1,330,633		Washington	4,134,934
9	Oregon	1,100,575	9	Idaho	867,768
				Oregon	2,790,993
10	Maine	975,902	10	Maine	791,372
	New Hampshire	623,932		New Hampshire	505,946
	Vermont	384,286		Vermont	311,622
	Massachusetts	5,304,297		Massachusetts	4,301,324
	Rhode Island	891,523		Rhode Island	722,948
	Connecticut	2,687,588		Connecticut	2,179,400
	New York	18,707,520		New York	15,170,174
	New Jersey	8,441,242		New Jersey	5,223,288
	Pennsylvania	11,942,263		Pennsylvania	9,684,138
	Minnesota	3,154,043		Minnesota	3,378,484
	Iowa	2,438,300		Iowa	2,611,809
	Missouri	3,994,521		Missouri	4,267,629
	North Dakota	554,921		North Dakota	594,409
	South Dakota	617,742		South Dakota	661,700
	Nebraska	1,261,031		Nebraska	1,350,765
	Kansas	1,970,911		Kansas	2,111,160
	Delaware	276,744		Delaware	422,599
	Maryland	1,930,607		Maryland	2,948,114
	District of Columbia	537,493		District of Columbia	820,773
	Virginia	2,262,448		Virginia	3,454,846
	West Virginia	1,083,872		West Virginia	1,655,116
	North Carolina	2,614,089		North Carolina	3,991,818
	South Carolina	1,388,037		South Carolina	2,119,587
	Georgia	2,147,179		Georgia	3,278,827
	Florida	2,747,637		Florida	4,196,752
	Alabama	1,726,985		Alabama	2,389,808
	Mississippi	1,106,722		Mississippi	1,531,487
	Kentucky	1,586,581		Kentucky	2,195,517
	Arkansas	697,486		Arkansas	1,148,527
	Louisiana	1,552,862		Louisiana	1,505,349
	Oklahoma	888,874		Oklahoma	1,463,678
	Texas	789,697		Wyoming	448,366
	Idaho	342,188		Colorado	2,373,908
	Wyoming	176,805		New Mexico	1,291,225
	Colorado	936,106		Arizona	1,869,931
	New Mexico	509,170		Utah	1,272,109
	Arizona	737,372		Nevada	446,049
	Utah	501,632		California	22,799,484
	Nevada	175,897			
	California	8,990,546			
Mexico	Texas	4,023,151	Mexico	Louisiana	1,051,696
				Texas	7,925,153

a/ Transportation rates computed on the basis of uniform increase in rate as distance increases.

b/ Region 1 did not produce a significant quantity of frozen berries in 1955 and so is omitted. Mexican imports are added, leaving a total of 10 regions.

There seems to be less agreement concerning the likelihood of a regional price-quality differential for frozen strawberries packed in large-size containers, especially for that portion used by the preserving industry. The strawberries usually desired for preserving are the Marshall variety of the northwest regions, but there are exceptions. Interviews with freezing and preserving plant managers in many areas of the country indicate that, while most preservers would like to use Marshall berries, they do not agree on the premium that should be paid. Opinions as to the premium that should be given range from zero--despite a stated preference for Marshalls--up to 1 cent per pound.

Although interregional price differentials based on quality characteristics are not now extensively used, there is considerable interest in the effect this could have on the industry. Since the northwest regions are presently recognized as having strawberries of distinctive quality characteristics, the effect of higher prices for berries from Regions 8 (Washington) and 9 (Oregon) is presented.

If we retain Model III with the single exception of valuing Regions 8 and 9 strawberries in both retail- and large-size containers just 1/4 cent per pound higher than strawberries from any other region, Region 8 production in large-size containers would increase more than 80,000,000 pounds. The entire increase would come at the expense of Region 10 and would represent a 57 per cent decrease of Region 10 production in large-size containers. The change in retail-size production would be negligible.

If the price differential were 1/2 cent per pound, Region 8 would increase production in large-size containers nearly 140,000,000 pounds. This would remove Region 2 from the industry and absorb 80 per cent of the production for large-size containers assigned to Region 10 in Model III. Retail-size production would still remain relatively unchanged.

A price differential of nearly 3/4 cent per pound is required to allow Region 8 to increase production in retail-size containers. At this price differential, Region 8 would assume over 100,000,000 pounds of the retail-size container production assigned to Region 10 in Model III--causing a decrease of 75 per cent in Region 10 production for retail-size containers. If the price differential were increased to 1 cent per pound, Region 10 would lose nearly 128,000,000 pounds (93 per cent) of the Model III retail-size container production to Region 8.

It is unlikely that all consumers will be willing to pay a price differential for northwestern strawberries. If there is in fact a quality difference, however, certainly some buyers will be willing to pay that differential. The effect of their willingness on the location of strawberry production will depend upon the

proportion of the total market they represent. It must also be emphasized that maintenance of the price differential would become increasingly difficult as the volume of premium quality product marketed increased. It can be seen, however, that rather small price differentials can result in large production shifts.

This model can also be used to demonstrate the sensitivity of results obtained to estimated costs employed. If an assumption is made of lower production costs in Regions 8 and 9 rather than higher price for the product, results similar to those of this model will be obtained.

Model VI--1970 Total Cost With Regional Technological Change

The consideration given in this study to the future location of production of strawberries for freezing is based almost exclusively on an assumption of static technology at the level existing in 1958. This is believed to be the best assumption that can be made with respect to technology, since it is based on known conditions, and any alternative would of necessity be based on presently unknown conditions. Model VI is presented, however, to show the hazards involved in the assumption of static technology.

A contributing factor in the recent rapid increase in Region 10 strawberry production has been the introduction of new, long-bearing, heavy-yielding varieties which are especially adapted to California growing conditions. Estimation of the reduction in per-unit farm production cost brought about by this change is precluded by absence of input-output data for the earlier period. However, if we assume that per-unit farm production costs are unchanged from the earlier period--although they probably have decreased because of increased yield--the change in season length has had sufficient impact on processing costs alone to give a total-unit-cost advantage to Region 10. This means that reversion in Region 10 to the 200-hour season applicable in Regions 1, 2, 8, and 9 would result in processing costs in Region 10 sufficiently greater than determined in this study to cause the total-unit-cost advantage now held by Region 10 to shift to Region 8 for all consuming regions except California.

The effects of technical advances in Region 10 could, of course, be modified by future technical developments in other regions. This is illustrated in Model VI by assuming that it becomes possible to produce 50 per cent more strawberries per year on a given bearing acreage of Region 2 and that this increases the length of the producing season 50 per cent. Harvesting costs are assumed to increase 50 per cent (proportionately with yield) but nonharvesting costs to remain as before the technical change. With these assumptions, farm production cost would decrease about 1.44 cents per pound, resulting in a finished product cost decrease of 1.28 cents per pound.

The increased length of processing season--from 200 to 300 hours in Region 2--enables the spread of fixed costs of a given processing plant over more product. This saving would approximate 0.18 cent per pound of product in 30-pound tins and 0.28 cent per pound in 10-ounce cartons.

The f.o.b. processing plant costs applicable to Region 2 under these conditions would be 15.04 and 19.48 cents per pound for strawberries packed in 30-pound tins and 10-ounce cartons, respectively. While these costs are still higher than those of Regions 8 or 10, the decrease of only about 1.5 cents per pound of frozen product could make Region 2 the most important strawberry producing area in the United States.

Figures 7 and 8 show the theoretical market areas of the regions which could remain in strawberry production under these assumptions. The heavy lines in these figures are the market boundaries for producing regions. Numbers appearing within state boundaries indicate the producing region which the programming solution would assign as the supply source for that state. If a producing region number falls outside the boundary for its market area, it indicates that the consuming "point" falls within the boundary, although a large part of the land area of the state falls outside the boundary.

The boundary of the Region 2 market area is as should be expected, since it extends farther to the east--away from the regions which produce at a lower at-processing-plant cost--than to the west. The boundaries of Regions 8 and 10 are of unusual shape because of the transportation cost relationships used. The sharp break upward in this boundary line is at the point where rail transport becomes the least-cost method for Region 10. The very small increase in rail transportation cost as distance increases in comparison with the truck transportation costs of Region 8 forces the boundary abruptly upward. The market-area boundary for Mexican imports cannot be shown because Mexican production and processing costs are unknown. Total transportation cost is minimized by allocating Mexican imports to the states indicated by "M."

The boundaries of Regions 8 and 9 are the same in this model as in Model III, because Region 2 would still be unable to compete in their market areas. Region 2 is shown to supply both retail and large-size containers to most of the eastern half of the United States and none of the other eastern regions would produce. Region 10, which under similar conditions and present techniques (Model III) would produce nearly all of the United States strawberries, would decrease production to only about 25 per cent of this volume. Region 2 would increase production to over 225,000,000 pounds--more than 70 per cent of the strawberries consumed in the United States.

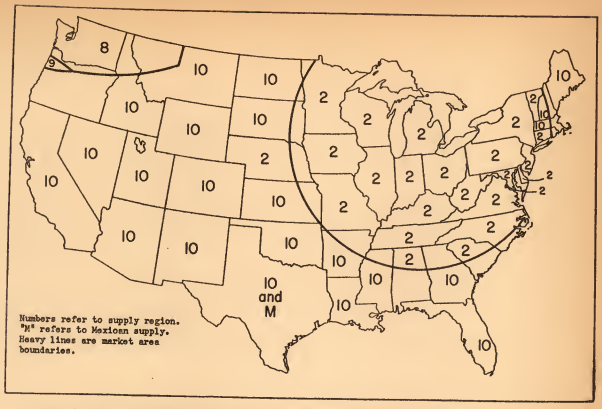

Figure 7. Optimal distribution pattern for frozen strawberries packed in retail-size containers with assumed Region 2 cost-reducing technological change--Model VI--1970.

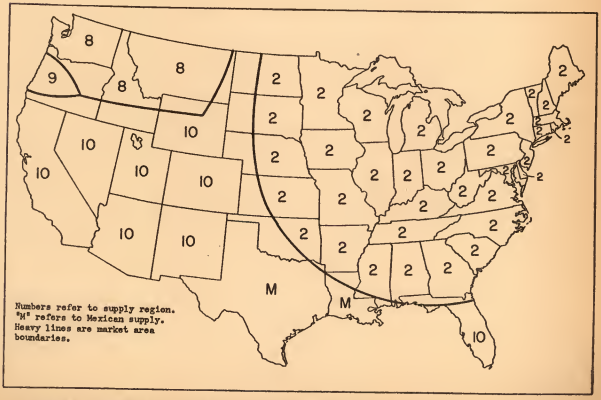

Figure 8. Optimal distribution pattern for frozen strawberries packed in large-size containers with assumed Region 2 cost-reducing technological change--Model VI--1970.

Region 10 would still hold a competitive advantage over about half of the area of the United States. Much of this area, however, is sparsely populated. Region 2, being comparatively near major population centers, would hold a comparative advantage in about the same amount of land area as Region 10 but with a population approximately three times as large.

Similar advantages could be gained by any other eastern region if it could develop techniques which reduced total product cost to approximately the level assumed for Region 2 in this example. Because they lack the transportation cost advantage of eastern regions, Regions 8 and 9 would require f.o.b. plant cost reductions to levels below those of Region 10 if they were to capture the eastern markets.

Model VII--Unrestricted Total Cost With an Increase in Region 10 Labor Cost

In the foregoing discussion of future production location, it has been assumed that all production and processing costs will remain at 1957-58 levels; or that if changes do occur they will be in the same direction, with the same amount of change in all producing regions. A more realistic assumption--based on recent experience--may involve generally rising costs, but at a different rate, in some regions. Unusually rapid growth in population and in industrial and urban development may, for example, create heavier upward pressure on wage rates for processing plant labor in California than in many other states. Wage rates for farm labor in California might be similarly affected if widely used Mexican national labor should become less readily available or if local competitive conditions should require higher wage levels relative to other regions than currently prevail. Model VII, therefore, is designed to show the effect of an increase in production and processing labor cost in California (Region 10) relative to other regions.

Only a very small labor cost increase in Region 10 is required to shift the production advantage for certain consuming areas to other producing regions. If, for example, Region 10 costs are assumed to advance 5 per cent--while all the costs of other producing regions remain constant--this region loses its cost advantage for all except 15 per cent of the United States production in large-size containers. Most of this loss would be a gain by Region 8, although Region 2 would become the low-cost region for 11 per cent of United States consumption in large-size containers. The effect on retail-size containers would be relatively small, with Region 10 losing about 7 per cent of United States consumption to Regions 2 and 8.

If Region 10 labor costs advanced 10 per cent relative to the other regions, a more drastic change would occur. Region 10 would then lose its advantage for production in retail-size cartons, as well as large-size containers. Region 2 would obtain an advantage in production for 58,000,000 pounds more than in Model III, Region 4 would gain 2,000,000 pounds, and Region 8 would gain 220,000,000 pounds. These gains by other regions would represent a loss on the part of Region 10 of about 88 per cent of its Model III production.

Model VIII--1970 Unrestricted Total Cost With Per-Capita Consumption Increase

The above models assume per-capita consumption of frozen strawberries to remain at the 1955 level. There are, however, indications of recent upward trends in per-capita consumption. While the evidence is not adequate for forecasting 1970 consumption rates, it suggests examination of the production allocation that would result with continued growth in per-capita consumption. Model VIII, therefore, is based on the assumption that the average growth rate during the period 1954-1958 will continue to 1970.

The trend in total frozen strawberry consumption, 1954-1957, amounted to an average annual increase of about 0.026 pounds per person.[1/] On the assumption of similar annual increases to 1970, per-capita frozen strawberry consumption in the United States would increase about 25 per cent above the 1955 level to a total of about 2.0 pounds per capita. If this increase is divided between large-size and retail-size containers in the proportion estimated for 1955, the increase in large-size container consumption would be 0.215 pounds per person; retail-size container consumption would increase by 0.180 pounds per person.

Since each consuming region in this model would be supplied by the same producing region as in Model III, the changes are in quantity demanded from certain producing regions. The single exception to this generalization occurs in the case of Mexican supplies, where constant Mexican imports are assumed. California would be the source of increased supply for regions receiving some product from Mexico.

With the assumed per-capita consumption of this model, total United States frozen strawberry consumption would increase to 402,300,000 pounds from the 321,600,000 pounds of Model III. Of this increase, Washington would supply 1,400,000; Oregon, 1,300,000; Tennessee (Region 4), 700,000; and California, 77,300,000 pounds. The new total allocated for production in California would be approximately 374,000,000 pounds.

1/ U. S. Agricultural Marketing Service, Fruit and Vegetable Division, Marketing California Strawberries, 1958 Season (San Francisco: Federal-State Market News Service, May, 1959), p. 48.

Model IX--1970 Increased Per-Capita Consumption With Restricted Regional Production

The study of production-consumption flows thus far has assumed that the output of any producing region can be increased to any desired level without increase in farm-supply price. Even under the special circumstances applicable to the frozen strawberry industry, however, very large increases in the output of some regions may be possible only with increased farm-supply price. This would restrain regional output expansion. While there are no available forecasts of these effects, some implications of regional output restriction can be observed by assigning selected limits to output expansion in any region. This is attempted in a final model in which production-consumption flows are determined on the basis of a projected regional consumption 25 per cent higher than 1955 (as in Model VIII) and an assigned limit on output expansion in any producing region. The production limits chosen, as given in Table 13, permit expansion of output in any producing region to a level 75 per cent higher than the regional average production for processing during the period 1953-1957. Imports from Mexico are fixed at 1955 levels, and--for convenience in the problem solution--the retail and large-size Mexican pack is treated as originating in two producing regions.1/

When total regional output is restricted, the additional problem of its allocation to retail and large-size containers must be considered. The proportion now packed in different size containers varies among regions; all regions have some output in large-size containers, and in most regions, roughly equal quantities are packed in each category. Since all regions will have some output not suitable for retail pack, but of quality adequate for large-size pack, an additional assumption is made--namely, that at least 25 per cent of the output of any region would be used in large-size containers. Within this limitation, total production, processing, and distribution costs are to be minimized.

- - - -

TABLE 13

Regional Production Limitations, Total Output of Frozen Strawberries, Assumed for Model IX

Region	Principal producing state	Regional production limits[a/]
		thousand pounds
1	New York	0
2	Michigan	24,160
3	Virginia	4,490
4	Tennessee	36,304
5	Arkansas	8,880
6	Florida	3,668
7	Louisiana	6,958
8	Washington	63,000
9	Oregon	140,382
10	California	212,862
	Mexico[b/]	13,000

a/ Except for Mexico, regional production limitations were computed as 1.75 times the 1953-1957 average annual regional processed output. (Annual volume data taken from U. S. Agricultural Marketing Service, Fruit and Vegetable Division, Marketing California Strawberries, 1957 Season (San Francisco: Federal-State Market News Service, May, 1958), p. 34.

b/ Approximate amounts imported from Mexico in 1955 and consisting of 4,000,000 pounds in retail-size containers and 9,000,000 pounds in large-size containers.

A production-consumption pattern based on the above specifications is illustrated in Figures 9 and 10. As in Model III, Region 10 (California) is the source of the retail-size pack for most of the United States. Exceptions are the portion of Texas consumption supplied by Mexico and consumption in the northern tier of states (Oregon and Washington, through Maine) supplied by Regions 8 and 9. Under the regional output restrictions of this model, Region 10, however, plays a much less dominant role in the production of the large-size pack. Region 10 would satisfy local consumption needs (California) as well as Nevada and the southern tier of states, plus Oklahoma. Region 8 would supply most of the northern tier of states (excepting Michigan--supplied by Region 2--and a part of the New York requirements--shared with Region 9). The remaining states would be supplied by Region 9, with the exception of Illinois (supplied by Regions 2 and 8) and Tennessee and part of Kentucky (supplied by Region 4).

In terms of total volume of retail pack, Table 14 shows that, under the conditions of Model IX, Region 10 would supply roughly 140,000,000 pounds (77 per cent of the total retail pack). The remaining supply would come from Region 8 (22,000,000 pounds and 12 per cent of the total), Region 9 (16,000,000 pounds and 8.7 per cent of the total), and Mexico (4,000,000 pounds and 2.2 per cent). Of the large-size pack, the major portion in this model would be supplied by Region 9 (Oregon), which would produce approximately 107,000,000 pounds (48.5 per cent of the total). Region 10 production would be about 46,500,000 pounds (21.1 per cent) while that of Region 8 would be about 33,100,000 pounds (15.0 per cent). Roughly 21,100,000 pounds (9.6 per cent) would be produced in Region 2. The remainder would be supplied by Region 4 (4,000,000 pounds) and Mexico (9,000,000 pounds).

SUMMARY AND CONCLUSIONS

The frozen strawberry industry has developed with exceptional rapidity in the years since World War II. This growth has been largely concentrated in the states of California, Oregon, and Washington; and, based on production, processing, and shipping costs of 1957-58 as developed in this study, these states are expected to continue as industry leaders.

Farm-production-cost differences among regions are the largest of the three cost categories considered. The three western regions--California, Oregon, and Washington--were found to have production costs of 1.8 to 2 cents per pound less than any other region.

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Example Bar Chart Data

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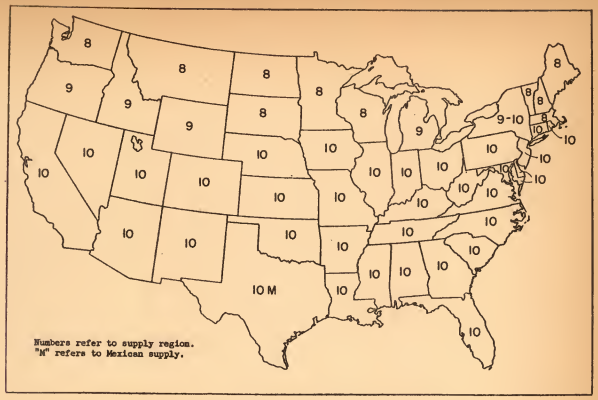

Figure 9. Production-consumption pattern with increased per-capita consumption, 1970, and restricted expansion in regional production--Model IX: retail pack.

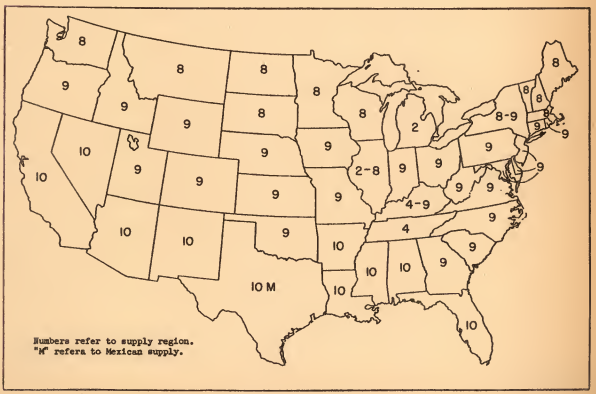

Figure 10. Production-consumption pattern with increased per-capita consumption, 1970, and restricted expansion in regional production--Model IX: large-size pack.

TABLE 14

Estimated 1970 Production-Consumption Balance for Frozen Strawberries Packed in Retail- and Large-Size Containers, with Increased Per-Capita Consumption and Restricted Regional Production[a/]

Retail size			Large size		
Producing region[b/]	Distribution		Producing region[b/]	Distribution	
	Consuming region	Amount		Consuming region	Amount
		pounds			pounds
			2	Illinois	9,836,040
				Michigan	11,303,960
			4	Kentucky	435,578
				Tennessee	3,494,066
8	Maine	1,219,878	8	Maine	989,215
	New Hampshire	779,915		New Hampshire	632,432
	Vermont	480,358		Vermont	389,528
	Massachusetts	6,630,371		Massachusetts	5,376,655
	Wisconsin	5,037,139		New York	5,789,549
	Minnesota	3,942,554		Illinois	2,808,421
	North Dakota	693,651		Wisconsin	5,090,828
	South Dakota	772,178		Minnesota	4,223,105
	Montana	422,024		North Dakota	743,011
	Washington	2,038,166		South Dakota	827,125
				Montana	1,070,229
				Washington	5,168,668
9	New York	2,499,425	9	Rhode Island	903,685
	Michigan	11,184,746		Connecticut	2,724,250
	Idaho	427,735		New York	13,173,169
	Wyoming	221,006		New Jersey	6,529,110
	Oregon	1,375,719		Pennsylvania	12,105,172
				Ohio	13,140,669
10	Rhode Island	1,114,404		Indiana	6,296,589
	Connecticut	3,359,485		Iowa	3,264,761
	New York	20,884,975		Missouri	5,334,536
	New Jersey	8,051,552		Nebraska	1,688,456
	Pennsylvania	14,927,829		Kansas	2,638,950
	Ohio	13,002,085		Delaware	528,249
	Indiana	6,232,162		Maryland	3,685,142
	Illinois	12,511,110		District of Columbia	1,025,966
	Iowa	3,047,875		Virginia	4,318,558
	Missouri	4,980,151		West Virginia	2,068,895
	Nebraska	1,576,289		North Carolina	4,989,772
	Kansas	2,463,639		South Carolina	2,649,484
	Delavare	345,930		Georgia	4,098,534
	Maryland	2,413,259		Kentucky	2,308,818
	District of Columbia	671,866		Alabama	2,129,576
	Virginia	2,828,058		Oklahoma	1,829,598
	West Virginia	1,354,840		Idaho	1,084,710
	North Carolina	3,267,611		Wyoming	560,458
	South Carolina	1,735,046		Colorado	2,967,385
	Georgia	2,683,974		Utah	1,590,136
	Florida	3,434,346		Oregon	3,488,741
	Kentucky	1,983,226			
	Tennessee	2,524,972	10	Florida	5,244,690
	Alabama	2,158,731		Alabama	857,684
	Mississippi	1,383,402		Mississippi	1,914,359
	Arkansas	871,858		Arkansas	1,435,659
	Louisiana	1,941,078		Louisiana	3,196,306
	Oklahoma	1,111,092		Texas	906,441
	Texas	2,016,060		New Mexico	1,614,031
	Colorado	1,170,132		Arizona	2,337,414
	New Mexico	636,462		Nevada	557,561
	Arizona	921,715		California	28,499,355
	Utah	627,040			
	Nevada	219,864			
	California	11,238,182			
Mexico	Texas	4,000,000	Mexico	Texas	9,000,000

a/ Based on projected increase to per-capita consumption rate 25 per cent higher than 1955; with production expansion in any region limited to a 75 per cent increase over average regional production for processing during the period 1953-1957.

b/ Region 1 did not produce a significant quantity of frozen strawberries in the period 1953-1957 and so is omitted. Mexican imports are added, leaving a total of ten regions.

Processing-cost differences among regions are comparatively small but, when included with other costs, are often sufficient to shift delivered processed product cost advantage among regions. Important determinants of regional processing costs are wage rates and other factor prices, processing techniques employed, and length of processing season. California, due to the longer processing season and in spite of higher wage rates, is able to process strawberries for freezing at a lower cost than any other region. All regions other than California have strawberry freezing seasons of approximately the same length (150-200 hours as compared with 1,000 hours in California) and have relatively little difference in processing costs. Regions 1 and 2 of this study (represented by New York and Michigan) follow California in processing cost advantage. The processing costs of these regions are slightly lower than the next group--Regions 3, 4, 5, 6, and 7 (represented by Virginia, Tennessee, Arkansas, Florida, and Louisiana)--because of their slightly longer processing season. Because of higher wage rates, Regions 8 and 9 (Washington and Oregon) have higher processing costs than other regions of similar length of processing season.

The cost of frozen strawberries at a freezing plant in each region is composed of the costs of farm production and processing the berries for freezing, plus the costs of sugar, containers, and freezing. California, followed closely by Washington and Oregon, holds an advantage in total at-plant processed (frozen) product cost. Among eastern producing areas, Regions 2 and 4 (Michigan and Tennessee) have lowest total frozen product cost.

The final cost category considered is transportation. Both rail and truck transport are used to move frozen strawberries, and the lowest-cost method was assumed to be utilized in each interregional movement. Truck transport was estimated to be most economical at distances of less than 1,220 miles and rail transport most economical at greater distances. Rail rates are established on a zone basis, resulting in equal transportation costs over large areas from a given shipping region. In the consideration of a past period--1955--appropriate zone rates were utilized. However, for simplification, continuous rail and truck transport cost-distance relationships were utilized in the estimation of future transport costs.

The total cost of frozen strawberries in each consuming region was determined for each producing region from the at-plant processed-product and transportation costs. Within-consuming-region distribution and retailing costs were omitted from the analysis on the assumption that they would be the same regardless of origin of product and would have no influence on a determination of origin of product.

The best available data on regional consumption and production for 1955 were used as the basis of separate determinations of interregional product flows which: (1) represent the distribution pattern for the 1955 regional output that would have minimized the total cost of transporting that produced supply to the consuming regions; and (2) show the location of 1955 production and its distribution to consuming regions that would have resulted in least total cost of production, processing, and transportation of the amounts of frozen strawberries consumed in the various consuming regions in 1955. This analysis indicated that adjustment to a basis of least total cost would have required a considerable change in production location, with California producing 92 per cent of the frozen strawberries. The savings in total cost, however, would have been only 2.6 per cent. There was, therefore, little incentive for further adjustment toward a least-cost production and distribution pattern beyond that already achieved in the frozen strawberry industry in 1955.

Studies of economical adjustments that may be appropriate in the future were based on estimated 1970 regional consumption estimates and 1957-58 production, processing, and transportation costs. When the location of 1970 production is projected entirely in terms of present indications as to least total cost of production, processing, and transportation (Model III), it appears that California would supply nearly all--93 per cent--of the frozen strawberries produced in the United States. Farm production and transfer costs in Washington and Oregon, however, are nearly equal to those in California, which makes these states close competitors. Only minor changes in cost structure favorable to the northwest would be required to demonstrate an expansion of frozen strawberry output there at the expense of California. Since the results of this study can thus be easily disturbed, several alternative formulations were considered.

The effects of uniformly proportional increases in transportation costs from all producing regions were examined (Model IV). A general increase of 10 per cent in transportation costs was shown to result in only minor adjustment in the solution based on current 1957 transportation costs. However, a 50 per cent increase in transportation cost would call for a decrease of about 28 per cent in Region 10 production and increased production in Regions 2 and 4 of 77,000,000 and 5,000,000 pounds, respectively.

The effect of regional product price differentials was considered (Model IV) by introducing several levels of price advantage for northwest berries--for which some expression of preference was encountered, especially for processed use. If the conditions of least total cost are retained--except for pricing frozen

strawberries of Regions 8 and 9, 1/4 cent per pound higher than the product of other regions--the output of Region 8 in large-size containers would increase by 80,000,000 pounds above the level indicated by Model III. An increase of 1 cent per pound would result in a transfer of nearly 128,000,000 pounds of retail-size output from Region 10 to Region 8. Expansion of this magnitude in Region 8 output would, of course, weaken the market for premium-price berries, and this would curtail the possibilities of realizing the production adjustments projected above.

The effects of a technical advance in eastern producing regions comparable to that contributing to the recent rapid expansion in Region 10 output were investigated by assuming a 50 per cent increase in per-acre yield and in length of processing plant operating season in Region 2 (Model VI). Such changes would reduce total processed cost in Region 2 by about 1.5 cents per pound and would provide it with a production-processing-transportation cost advantage over much of the most populous areas of the United States. The resulting increase in Region 2 production would make it the source of 70 per cent of total United States production of frozen strawberries.

A small rise in farm and processing plant labor costs in Region 10 (California) relative to other producing regions was found in Model VII to greatly reduce the comparative advantage of California in frozen strawberry production. An increase of 5 per cent in Region 10 labor costs--with all other conditions as assumed in Model III--reduced the Region 10 allocation of estimated 1970 production from 93 to only 15 per cent of total United States production in large-size containers. Except for an 11 per cent increase in Region 2 production of large-size containers, reduced output in Region 10 would be offset by increased production in Region 8. A 7 per cent reduction in Region 10 production in retail-size containers would be taken up by Regions 2 and 8. A considerably more drastic change would follow if Region 10 labor costs were to advance by 10 per cent relative to costs in other regions. A loss of about 88 per cent of the output allocated in Model III would be experienced by Region 10, while an increase of 58,000,000 pounds would occur in Region 2 and there would be increases of 2,000,000 and 220,000,000 pounds in the output of Regions 4 and 8.

When Model III is adjusted to the basis of 1970 per-capita consumption reflecting continuation of the average rate of growth prevailing during the period 1954-1958, estimated per-capita consumption increases from the 1955 level of 1.58 pounds to 2.0 pounds in 1970. Total United States consumption then would be approximately 402,000,000 pounds as compared with the 322,000,000-pound total on which Model III is based. If this increased output is allocated among producing

regions on the basis of no increase in supply price in any region as a result of increased output, most of the increased consumption would be supplied by Region 10. The Region 10 output would be roughly 374,000,000 pounds, an increase of 77,300,000 pounds over the amount allocated in Model III. The output in Region 8 (Washington) would increase over the Model III allocation by 1,400,000 pounds, and gains of 1,300,000 and 700,000 pounds would occur in Region 9 (Oregon) and Region 4 (Tennessee).

When the increased 1970 consumption of Model VIII is considered along with a selected restriction on regional production expansion (Model IX) the proportion of total production allocated to California decreases from the roughly 93 per cent of Model III to about 44 per cent. Most of the drop in California production would occur in the large-size container category. The principal producing areas benefiting from such a shift would be Regions 8 and 9 (Washington and Oregon), with substantial gains also occurring in Michigan and minor gains in Tennessee.

Based on the present structure of costs of production, processing, and shipping frozen strawberries, Region 10 holds a total unit cost advantage in nearly all of the United States markets. The margin of advantage is slight, however, and small changes in certain cost components could eliminate a large part of it. This possibility directs attention again to the assumption of constant regional production costs over wide ranges in regional output that was applied throughout the analysis. It means that small departures from this assumption in the direction of increased supply price as output expands in the major producing regions--such as the Pacific Coast states and Michigan--would substantially reduce the heavy allocations of production to these regions that are suggested by several of the analytical models. Moreover, the differences in total average costs of production and processing among Regions 8, 9, and 10 are so small that these costs might well be considered equal. It seems especially reasonable, in view of their similarities as to location, production conditions, and costs, to consider the total average costs in Regions 8 and 9 to be equal. If this were the case, production individually allocated to each of these regions should be jointly allocated to both regions.

The margin of total-unit-cost advantage for any producing region is too slight to warrant a strong statement as to the future regional growth of the frozen strawberry industry. It is probable that Regions 8, 9, and 10 (the Pacific Coast states) will remain dominant in this industry, but not likely that Region 10 (California) will produce nearly all the United States frozen strawberries as the total-cost analysis of Model III suggests. The location of future regional growth--and decline--of this industry will depend upon presently unknown developments, as exemplified by the results of Models IV to IX described above.

APPENDIX TABLE A

Estimated Costs of Transporting Frozen Strawberries in 10-Ounce Cartons Between Selected Points in Producing and Consuming Regions Net Weight Basis, 1958/

Consuming state	Producing region										
	1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	136	203	168	247	203	229	229	252	252	252	282
New Hampshire	125	191	160	220	203	229	229	252	252	252	282
Vermont	121	188	164	217	203	229	229	252	252	252	282
Massachusetts	128	194	155	218	203	229	229	252	252	252	282
Rhode Island	127	194	149	173	203	229	229	252	252	252	282
Connecticut	122	183	136	199	203	229	229	252	252	252	282
New York	101	171	145	200	203	229	229	252	252	252	282
New Jersey	113	167	117	181	203	216	229	252	252	252	258
Pennsylvania	103	177	109	167	213	208	229	252	252	252	258
Ohio	94	96	148	133	171	218	209	247	247	247	258
Indiana	132	95	163	104	140	201	177	247	247	247	258
Illinois	137	79	183	127	146	223	190	229	229	229	258
Michigan	122	58	168	138	170	247	210	247	247	247	258
Wisconsin	149	97	194	139	156	247	200	229	229	229	258
Minnesota	194	147	252	179	149	247	225	221	221	229	258
Iowa	182	135	225	155	113	247	191	221	221	221	258
Missouri	180	139	210	124	86	218	162	221	221	221	236
North Dakota	252	191	252	224	181	252	229	211	211	211	258
South Dakota	203	163	252	192	138	252	220	211	211	211	258
Nebraska	200	153	252	171	113	252	196	211	211	211	236
Kansas	225	183	252	165	85	252	168	211	211	211	236
Delaware	123	167	81	177	203	212	229	252	252	252	258
Maryland	116	154	95	164	215	198	226	252	252	252	258
District of Columbia	120	155	87	159	215	193	221	252	252	252	258
Virginia	132	166	61	151	221	179	213	252	252	252	258
West Virginia	124	133	122	122	179	187	198	252	252	252	258
North Carolina	150	179	69	141	211	158	196	252	252	252	258
South Carolina	174	183	118	128	199	132	171	252	252	252	258
Georgia	198	185	145	112	180	118	145	252	252	252	258
Florida	243	247	180	163	223	0	164	252	252	252	258
Kentucky	139	115	158	82	143	187	168	247	247	247	258
Tennessee	163	141	161	0	139	163	143	247	247	247	236
Alabama	190	169	168	88	150	140	119	247	247	247	236
Mississippi	216	187	201	120	140	159	78	247	247	247	236
Arkansas	208	174	208	113	100	192	114	221	221	221	236
Louisiana	252	210	221	143	152	164	0	229	229	221	211
Oklahoma	252	199	252	161	92	252	147	229	229	211	236
Texas	252	247	252	170	128	217	126	229	229	211	211
Montana	252	247	252	247	229	252	229	175	193	211	258
Idaho	252	247	252	247	229	252	229	140	128	166	258
Wyoming	252	227	252	247	229	252	229	211	211	211	258
Colorado	252	225	252	225	162	252	226	211	211	211	236
New Mexico	252	247	252	247	169	252	229	229	229	211	211
Arizona	252	247	252	247	229	252	205	183	183	161	211
Utah	252	247	252	247	229	252	205	189	177	178	236
Nevada	252	247	252	247	229	252	229	169	138	107	236
Washington	252	247	252	247	229	252	229	0	92	191	258
Oregon	252	247	252	247	229	252	229	92	0	162	258
California	252	247	252	247	229	252	205	208	177	87	211

a/ Estimated from gross transportation rates (Table 4) by adjusting to net weight basis. Adjustment ratio is 1.16667.

APPENDIX TABLE B

Estimated Costs of Transporting Frozen Strawberries in 30-Pound Tins Between Selected Points in Producing and Consuming Regions Net Weight Basis, 1955a/

Consuming state	Producing region										
	1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	124	185	154	226	186	209	209	230	230	230	258
New Hampshire	114	175	146	201	186	209	209	230	230	230	258
Vermont	111	172	150	198	186	209	209	230	230	230	258
Massachusetts	117	178	141	199	186	209	209	230	230	230	258
Rhode Island	116	177	136	158	181	209	209	230	230	230	258
Connecticut	112	168	124	182	186	209	209	230	230	230	258
New York	92	157	132	183	186	209	209	230	230	230	258
New Jersey	103	153	107	166	186	197	209	230	230	230	236
Pennsylvania	94	162	99	152	194	190	209	230	230	230	236
Ohio	86	88	135	122	157	199	191	226	226	226	236
Indiana	120	87	149	95	128	184	162	226	226	226	236
Illinois	126	72	167	116	134	204	174	209	209	209	236
Michigan	111	53	153	126	156	226	192	226	226	226	236
Wisconsin	136	89	177	212	143	226	183	209	209	209	236
Minnesota	177	135	230	164	136	226	206	202	202	209	236
Iowa	166	123	205	142	104	226	175	202	202	202	236
Missouri	165	127	192	113	79	200	148	202	202	202	215
North Dakota	230	175	230	204	165	230	209	193	193	193	236
South Dakota	186	149	230	176	127	230	201	193	193	193	236
Nebraska	183	140	230	156	104	230	179	193	193	193	215
Kansas	206	168	230	151	184	230	153	193	193	193	215
Delaware	112	153	74	162	186	194	209	230	230	230	236
Maryland	106	141	87	150	197	181	206	230	230	230	236
District of Columbia	110	142	80	145	196	177	202	230	230	230	236
Virginia	121	152	56	138	202	164	194	230	230	230	236
West Virginia	114	122	112	112	164	161	181	230	230	230	236
North Carolina	138	164	63	129	193	145	180	230	230	230	236
South Carolina	159	167	108	117	182	121	156	230	230	230	236
Georgia	181	169	132	102	165	108	132	230	230	230	236
Florida	222	226	165	149	204	0	150	230	230	230	236
Kentucky	127	105	145	75	131	171	154	226	226	226	236
Tennessee	149	129	147	0	127	149	131	226	226	226	215
Alabama	173	155	154	80	137	128	109	226	226	226	215
Mississippi	198	171	184	110	128	145	71	226	226	226	215
Arkansas	191	159	190	104	91	176	104	202	202	202	215
Louisiana	230	192	202	131	139	150	0	209	209	202	186
Oklahoma	230	182	230	147	85	230	135	209	209	193	186
Texas	230	226	230	156	117	199	115	209	209	193	152
Montana	230	226	230	226	209	230	209	160	177	193	236
Idaho	230	226	230	226	209	230	209	128	117	151	236
Wyoming	230	207	230	226	209	230	209	193	193	193	236
Colorado	230	205	230	205	148	230	207	193	193	193	215
New Mexico	230	226	230	226	154	230	209	209	209	193	190
Arizona	230	226	230	226	209	230	188	167	167	147	190
Utah	230	226	230	226	209	230	188	173	162	163	215
Nevada	230	226	230	226	209	230	209	155	126	98	215
Washington	230	226	230	226	209	230	209	0	84	175	236
Oregon	230	226	230	226	209	230	209	84	0	148	236
California	230	226	230	226	209	230	188	191	162	79	190

a/ Estimated from gross transportation rates (Table 4) by adjusting to net weight basis. Adjustment ratio is 1.06667.

APPENDIX TABLE C

Estimated Costs of Transporting Frozen Strawberries in 10-Ounce Cartons
Between Selected Points in Producing and Consuming Regions
Net Weight Basis, 1957

Consuming state	Producing region										
	1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	150.841	224.526	186.448	252.420	257.641	256.833	260.353	284.384	286.510	287.740	279.133
New Hampshire	138.197	211.882	176.856	244.146	256.176	255.721	259.241	282.838	285.045	286.274	277.668
Vermont	134.192	207.958	182.088	240.229	255.721	256.327	259.294	282.384	284.590	285.820	277.213
Massachusetts	141.539	215.224	171.188	241.239	256.599	255.064	258.584	283.226	285.432	286.662	277.566
Rhode Island	140.958	214.643	165.084	236.007	255.873	254.357	257.877	283.158	285.365	286.584	276.859
Connecticut	135.581	203.016	150.260	220.311	254.155	252.639	256.159	281.821	283.731	284.896	275.141
New York	111.383	189.791	160.142	222.055	253.616	253.784	256.681	280.278	282.485	283.714	275.107
New Jersey	125.008	185.140	130.107	200.836	252.083	238.918	253.902	279.739	281.659	282.751	272.884
Pennsylvania	114.153	167.118	120.260	184.529	235.571	230.484	252.016	277.651	279.520	280.666	270.998
Ohio	104.151	106.296	163.185	147.789	189.936	241.094	231.647	271.318	273.524	274.754	266.130
Indiana	115.754	105.128	181.071	114.933	151.765	222.636	196.621	269.633	270.610	271.301	262.054
Illinois	152.294	87.763	202.290	141.103	162.322	246.762	210.283	266.534	268.842	270.071	263.368
Michigan	134.854	64.794	186.012	152.140	188.773	251.931	232.229	270.004	272.177	273.406	266.111
Wisconsin	165.084	107.721	235.079	153.893	173.077	252.774	221.619	265.271	267.579	270.108	264.614
Minnesota	214.643	163.049	253.363	198.656	164.648	257.995	249.523	259.309	261.616	266.804	263.452
Iowa	201.127	149.242	248.942	172.060	125.725	254.819	212.027	262.192	263.081	264.311	259.107
Missouri	199.673	154.038	232.955	137.179	95.715	241.966	179.036	266.720	265.827	265.103	256.799
North Dakota	253.211	211.736	259.006	247.779	200.109	263.651	256.311	254.306	256.614	262.391	266.046
South Dakota	225.252	181.071	255.452	212.899	153.312	259.491	243.271	257.843	260.151	263.066	261.195
Nebraska	221.174	169.589	253.616	189.063	125.241	256.445	216.968	260.740	260.740	264.970	258.584
Kansas	249.233	203.016	255.485	183.105	93.610	254.727	186.012	263.536	262.256	259.309	253.262
Delaware	135.871	184.849	89.998	196.476	251.999	234.554	253.397	279.689	281.626	282.670	272.379
Maryland	128.201	170.326	105.213	181.797	238.187	219.875	250.250	278.021	279.941	281.171	270.678
District of Columbia	133.184	171.681	96.862	176.275	238.042	214.392	248.727	278.173	280.093	280.952	269.734
Virginia	146.481	184.413	67.426	167.118	244.582	198.366	235.571	279.520	281.255	281.221	268.977
West Virginia	137.906	147.789	135.435	135.581	198.365	207.376	219.727	274.568	275.899	276.404	265.086
North Carolina	166.682	198.801	76.242	156.364	233.827	175.548	217.550	280.480	281.833	279.975	266.888
South Carolina	192.843	202.289	130.288	142.266	220.456	146.190	189.645	280.110	280.783	277.415	263.651
Georgia	218.858	204.906	160.288	123.566	199.964	130.288	160.288	279.571	278.948	274.653	260.252
Florida	253.397	252.807	199.819	180.984	246.907	b/	181.652	285.836	284.984	278.948	262.761
Kentucky	154.184	127.184	175.548	90.487	158.253	207.522	186.157	271.537	272.059	271.756	261.145
Tennessee	181.071	155.928	178.455		153.602	180.384	158.548	273.693	273.069	270.509	258.315
Alabama	210.138	187.611	186.303	97.093	165.956	155.637	132.628	276.455	275.562	270.762	257.086
Mississippi	239.641	207.086	223.072	133.016	184.620	175.839	86.246	274.989	273.524	267.225	252.824
Arkansas	230.920	193.133	230.775	125.544	110.376	213.084	126.258	271.099	270.139	264.547	252.251
Louisiana	253.397	232.229	244.582	158.548	168.281	181.652		275.107	273.462	267.343	253.360
Oklahoma	259.948	220.020	255.334	177.873	102.431	253.060	163.194	265.608	264.143	258.551	240.222
Texas	266.641	251.931	266.361	188.773	142.121	240.949	139.069	268.909	267.144	260.825	196.040
Montana	262.610	256.631	268.404	260.774	254.104	273.053	263.873	194.005	213.916	253.700	269.600
Idaho	269.937	263.924	275.141	265.271	257.877	277.145	265.841	184.620	141.975	183.396	267.650
Wyoming	258.382	251.267	264.176	254.512	212.751	266.126	256.647	243.271	244.001	252.706	262.374
Colorado	257.506	248.797	261.684	248.942	179.181	263.284	250.686	255.148	253.683	254.323	257.372
New Mexico	261.667	256.311	264.665	252.639	187.175	261.077	231.066	257.338	255.873	228.886	245.018
Arizona	268.128	263.772	272.126	260.100	251.558	267.915	256.024	257.911	253.852	178.600	253.582
Utah	264.715	258.702	269.920	260.050	251.915	271.116	259.511	209.266	196.621	197.639	261.313
Nevada	273.625	267.612	278.830	268.960	260.690	278.493	266.888	187.756	152.730	118.949	266.787
Washington	275.528	269.589	281.322	273.693	266.804	284.836	275.107		213.213	214.643	276.910
Oregon	277.735	271.722	282.939	273.069	265.675	284.941	273.642	102.213		179.617	275.141
California	275.950	270.593	278.948	266.922	258.669	275.360	263.755	230.920	195.895	95.943	262.037

a/ Cost estimates for distances of 1,220 miles or less are 10.8 per cent higher than 1955 truck transportation estimates at these distances. Estimates for distances in excess of 1,220 miles are found from the following equation:

transportation cost = 231.34921 + 0.01684 3 (distance in miles as given in Table 3).

b/ Blanks signify zero transportation costs indicating that the same point has been chosen as both the production and consumption point.

APPENDIX TABLE D

Estimated Costs of Transporting Frozen Strawberries in 30-Pound Tins Between Selected Points in Producing and Consuming Regions
Net Weight Basis, 1957a/

Consuming state	Producing region										
	1	2	3	4	5	6	7	8	9	10	Mexico
	cents per 100 pounds										
Maine	137.912	205.281	170.467	230.785	235.559	234.820	238.038	259.937	261.954	263.079	255.209
New Hampshire	126.351	193.721	161.697	223.220	234.219	233.803	237.022	258.597	260.615	261.739	253.869
Vermont	122.690	190.133	166.481	219.632	233.803	234.358	237.006	258.181	260.199	261.323	253.454
Massachusetts	129.408	196.777	156.511	220.562	234.573	233.203	236.421	258.951	260.969	262.093	253.777
Rhode Island	128.876	196.245	150.934	215.778	233.942	232.556	235.774	258.890	260.907	261.985	253.130
Connecticut	123.960	185.615	137.380	201.128	232.371	230.985	234.204	257.658	259.113	260.111	251.559
New York	101.836	173.523	116.416	203.022	231.878	232.032	234.681	256.256	258.271	259.398	251.529
New Jersey	114.293	169.271	118.955	183.622	230.477	228.136	232.140	255.761	257.519	258.520	249.496
Pennsylvania	104.369	152.794	109.952	168.740	215.380	210.729	230.115	253.854	255.563	256.611	247.771
Ohio	95.223	97.157	119.472	135.121	173.656	220.429	211.792	248.064	250.081	251.205	243.320
Indiana	133.261	96.387	165.550	105.081	141.500	203.554	179.768	246.521	247.117	248.218	239.591
Illinois	139.211	80.241	184.951	129.009	148.409	225.611	192.259	243.690	245.800	246.924	240.795
Michigan	123.305	59.240	170.068	139.374	172.593	230.338	212.321	246.842	248.849	249.973	243.367
Wisconsin	150.934	98.188	196.644	140.702	158.242	231.108	202.623	242.535	244.645	245.232	241.934
Minnesota	196.245	149.074	231.647	181.629	150.535	235.882	228.136	237.083	239.193	240.236	240.872
Iowa	183.488	136.460	227.665	157.312	134.949	233.033	193.853	239.994	240.533	241.667	236.899
Missouri	182.559	140.835	212.988	125.121	87.511	221.226	163.690	243.869	243.043	242.281	231.789
North Dakota	231.509	193.588	236.806	226.514	182.958	241.057	234.342	232.510	234.619	239.902	243.243
South Dakota	205.945	165.550	233.557	194.661	140.171	237.253	222.422	235.744	237.853	240.518	238.808
Nebraska	202.491	155.053	231.878	172.959	134.783	234.465	198.371	238.392	238.392	239.517	236.421
Kansas	227.870	185.615	233.586	167.411	85.586	232.895	170.068	240.949	239.778	237.083	231.555
Delaware	121.225	169.005	82.284	179.636	230.400	231.450	231.678	255.717	257.188	258.243	249.034
Maryland	117.212	155.718	96.195	166.215	217.772	201.029	228.800	254.193	255.948	257.073	247.178
District of Columbia	121.768	156.913	88.556	161.166	217.639	195.980	223.751	254.331	256.087	256.872	246.616
Virginia	133.926	168.607	61.846	152.794	223.618	181.363	215.380	255.563	257.150	257.119	245.923
West Virginia	126.086	135.121	123.827	123.960	181.363	189.601	200.896	251.036	252.252	252.714	242.366
North Carolina	152.396	181.762	69.707	142.961	213.785	160.501	198.903	256.411	257.668	255.979	244.013
South Carolina	176.311	184.953	119.121	130.079	203.560	133.660	173.390	256.102	256.718	253.638	241.055
Georgia	200.099	187.342	146.549	112.975	182.825	119.121	146.549	255.610	255.040	251.113	237.916
Florida	231.678	231.139	182.692	164.886	225.714	b/	166.082	261.338	260.522	255.040	240.240
Kentucky	140.968	116.246	160.501	82.731	144.689	189.731	170.201	248.244	248.711	248.144	238.762
Tennessee	162.561	122.563	163.139		140.242	164.886	144.954	250.235	249.665	247.321	236.175
Alabama	192.126	147.530	170.334	88.770	151.731	142.297	121.260	252.761	251.941	247.555	235.051
Mississippi	219.100	189.336	203.952	121.615	141.367	160.767	78.853	253.121	250.081	244.321	231.151
Arkansas	211.128	176.579	210.995	114.783	100.915	194.784	115.436	247.863	246.986	241.873	230.631
Louisiana	231.678	212.321	223.618	144.954	153.857	166.082		251.529	250.189	244.429	228.835
Oklahoma	231.268	201.162	233.149	162.628	93.651	231.370	149.206	248.843	241.503	236.390	229.632
Texas	234.619	230.338	234.388	172.593	129.939	220.296	127.149	248.861	244.522	238.469	229.237
Montana	210.302	234.635	245.399	238.123	232.325	229.660	241.257	177.377	195.581	231.955	246.493
Idaho	246.801	241.303	251.559	242.635	235.774	253.392	243.059	241.367	229.806	167.677	241.706
Wyoming	236.236	229.731	241.534	232.725	194.519	243.582	231.660	222.422	223.087	231.047	239.886
Colorado	235.436	227.472	239.255	227.605	163.823	240.718	229.199	233.280	231.940	232.525	235.312
New Mexico	239.239	234.342	241.981	230.985	171.131	238.700	211.261	235.282	233.942	229.267	224.017
Arizona	246.082	241.164	243.803	237.807	229.996	244.953	234.080	235.805	232.094	163.492	231.847
Utah	248.027	236.529	246.785	237.761	230.323	247.879	237.268	191.329	179.768	180.699	238.916
Nevada	250.173	244.676	254.932	245.908	238.346	254.624	244.013	171.663	139.639	108.753	243.921
Washington	251.914	246.147	257.211	250.235	243.936	261.338	251.529		93.452	196.245	253.176
Oregon	253.931	248.133	258.690	249.665	242.905	260.522	250.189	93.452		164.222	251.837
California	252.299	247.401	255.040	244.044	236.498	251.760	241.149	211.128	179.104	87.720	239.576

a/ Cost estimates for distances of 1,220 miles or less are 10.8 per cent higher than 1955 truck transportation estimates at these distances. Estimates for distances in excess of 1,220 miles are found from the following equation:

transportation cost = 211.5193i + 0.015400 (distance in miles as given in Table 3).

b/ Blanks signify zero transportation costs indicating that the same point has been chosen as both the production and consumption point.